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Geology of Desoto and Red River Parishes, Louisiana.

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GEOLOGY OF DESOTO AND RED RIVER PARISHES, LOUISIANA

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FOREWORD AND ACKNOWLEDGEMENTS

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INTRODUCTION

DeSoto Parish

DeSoto Parish is in northwestern Louisiana between the flood plains of the Red and Sabine Rivers. Created in 1843 by the Sixteenth Legislature of the state of Louisiana, the parish originally extended eastward to the Red River. With the establishment of Red River Parish in 1871 the boundary was moved westward to approximately the western edge of the Red River alluvial valley. The Parish has an area of eight hundred and seventy-two square miles and is included in the area covered by Townships 10-16 North and Ranges 10-16 West. Bayou Pierre River and Wallace Bayou separate it from Red River and Caddo Parishes on the east, Wallace Bayou and Red Bayou separate it from Natchitoches Parish on the southeast. Keatchie Bayou, Cypress Bayou, Wallace Bayou, and a line through the center of Township 14 North, Range 16 West, separate DeSoto from Caddo Parish to the north. An east-west line through the center of Township 10 North forms the boundary with Sabine Parish on the south. The Sabine River and a north-south line through the western sixth of Range 16 West separate the parish from Shelby and Panola Counties, Texas.

The Parish population is 31,106 (1930 census). Mansfield, centrally located on the divide between the Sabine and Red Rivers, is the principal town and parish seat.

History

The Parish was established by Act 88 of the Sixteenth Legislature of the state of Louisiana, and was named in honor of Hernando de Soto.

The history of this general region dates back to 1542 when de Soto crossed Red River in the vicinity of Fulton, Ark., and presumably followed the Red River and its adjacent lakes and bayous back to the Mississippi River. He did not pass through the immediate area of DeSoto Parish, however, but was the first white man in this general region. Pere Olnis visited the Indian tribes along the Red River and Rio Grande in 1544 and may have been in this area. Numerous other priests and traders followed Olnis (Fortier, 1914).

On March 13, 1682, La Salle took possession of all the land drained by the Mississippi and its tributaries in the name of France (Belisle, 1912). On this basis France originally had claim to approximately one-half the parish, as only the northeast half is drained by tributaries of the Mississippi. Around 1700, Bienville and St. Denys explored the Red River and may have passed through what is now DeSoto Parish. After 1702 the Indians of the area were repeatedly visited by Jesuit missionaries.

Some of the early settlers in the general area were Pedro Dolet, who in 1795 settled on Bayou Adayes or Adaise. In the same year, under the Spanish regime, Jacinto Mora was granted 207,360 acres on the east side of the Sabine River. Later this was sold by Mora to Ed Murphy, William Burr, Samuel Davenport, and L. Smith as the grant of Santa Maria Adelaide Ormegas. A portion of this "Las Ormegas Grant" is included in the southern portion of DeSoto Parish. The Crow family located a claim on the Sabine River in 1797. William Darby (a map of the state of Louisiana- 1816) passed through the parish in 1812 while engaged in making a map of the State of Louisiana. Dugan's Creek, Thief Creek, Bayou Bon Chasse, and Bayou Lantt are shown in the vicinity of the parish on this map as were the settlements of Soto (?), Bertrand, Wallace, and Gutasse.

Even after the purchase of the Louisiana territory by the United States in 1803 the area of the parish was questionably a portion of this nation. Spain still claimed all of Texas and the area of Louisiana between the Sabine River and the Arroyo Hando, a tributary of Red River seven miles west of Natchitoches, north along the Red River and south on an imaginary line to the Gulf. With the close of General Wilkinson's Sabine Expedition in 1806 and the withdrawal of the Spanish forces under General Herrera from this territory, the Sabine River was first considered as the western boundary of the Louisiana territory. Until 1820, however, when the river was designated as the western boundary, this area, including DeSoto Parish, formed a neutral strip between the territories of Spain and the United States.

About 1830 (Fortier, 1914), Logansport was established on the bluffs of the Sabine River. For a time it was a thriving port but its importance waned as other Texas and Louisiana towns were established. In 1835 Jehiel Brooks negotiated a treaty with Tehowahimmo, Mattan, Toockroach, and other chiefs and warriors of the Caddo Indian tribe by which a large tract of land, including what is now DeSoto Parish, was secured.

During the decade after 1840, migration from Georgia, the Carolinas, and Alabama occurred. In 1843 the parish was created and the name and location of the parish seat, Mansfield, was decided upon. The town was incorporated in 1847. The Mansfield Female College was founded in 1854, and a Baptist college was established in 1857 at the town of Keatchie.

The Battle of Mansfield (April 8, 1864) between General Banks' army and the Confederate forces commanded by General Richard Taylor occurred a short distance east of the town.

Red River Parish

Red River Parish is in northwestern Louisiana, immediately east of DeSoto Parish. The parish was created in 1871 from portions of Caddo, DeSoto, and Natchitoches Parishes, and takes its name from the Red River, which flows northwest-southeast through its western half. Its boundaries were altered by legislation in 1872 and again in 1878; since this time no additional changes have been made. Kyser (1938) gives an excellent summary of the acts enacted in the creation of the boundaries. Approximately one-third of the land area consists of Red River flood plain; the remaining two-thirds consists largely of uplands between the Red River and Black Lake Bayou. In 1930 the parish had an area of 471 square miles (256,000 acres), a population of 16,078 people, and was included in the area of Township 11 North, Ranges 9 and 10 West, Township 12 North, Ranges 7-11 West, Township 13 North, Ranges 8-11 West, and Township 14 North, Ranges 8-12 West. An east-west line between Townships 14 and 15 North separates Red River Parish from Bienville, Bossier, and Caddo Parishes on the north; Bayou Pierre serves as the boundary line on the western side between Red River and DeSoto Parishes; Bayou Pierre, Bayou Lumbro, a north-south line between Ranges 8 and 9 West, and an east-west line between Townships 11 and 12 North separate the Parish from Natchitoches Parish to the south; and Black Lake Bayou and Black Lake serve as boundaries on the east, dividing Red River from Bienville and Natchitoches Parishes. The parish is drained by the Red River system and its tributaries. Coushatta, the parish seat, is the largest town.

PHYSIOGRAPHY

Introduction

Three simple, primary topographic provinces are found within the parishes. Most obvious are the alluvial valley or floodplain areas which are particularly well developed along the Red and Sabine Rivers and along their major tributaries. The Prairie Terrace surface constitutes a second topographic province; it borders the flood plains of the major streams and swings upstream along each tributary. The "hills areas", or third province, is geologically, as well as topographically, divisible into at least two sub-provinces, namely: (1) Terrace Uplands, and (2) Tertiary Uplands.

Dissected terrace levels* corresponding to the Montgomery and Bentley Terrace surfaces described by Fisk (1938 A) from Grant and La Salle Parishes and extended by Huner (1939, Winn and Caldwell Parishes), Russell (Personal communication, Jackson and Bienville Parishes), Rukas (Personal communication, Natchitoches Parish), Fisk (1940, Rapides Parish), and by Welch (Bulletin 22, Louisiana Geological Survey, Vernon Parish), constitute the terrace uplands.

* The surfaces formed during the Pleistocene stages are referred to as terraces or terrace surfaces. The deposit formed at this time and underlying the surface is a formation.

The Alluvial Valleys Section

The alluvial valleys, broad belts of alluvial materials, confined within well-defined valley and walls, include the following divisions in DeSoto and Red River Parishes: (1) Red River flood plain and tributary valley flood plains, (2) Sabine River flood plain and tributary flood plains, and (3) Black Lake Bayou flood plain and tributary flood plains.

The Red River Alluvial Valley

The flood plain of the Red River occupies the eastern edge of DeSoto Parish and the western one-quarter of Red River Parish. It averages between seven and eight miles in width when considered at approximately right angles to the present course of the river. Its greatest width in this area is near the Caddo-Red River Parish line where it is approximately ten miles across. The valley narrows to about five miles between Grand Bayou and Gahagan. The flood plain covers an area of approximately seventy-five square miles in DeSoto Parish and of approximately two hundred square miles in Red River Parish. The Red River itself is situated in the eastern half of the floodplain area and occupies a course roughly parallel to the DeSoto-Red River Parish line but from two to five miles to the east.

Both the eastern and western valley walls are relatively steep and attain a maximum height above the flood plain of slightly more than seventy-five feet. The western valley wall is characterized by several large floodplain re-entrants (see geologic map, plate I); the eastern valley wall by an absence of these large re-entrants.

The floodplain area is divisible into two main parts, namely: (1) natural levee area, and (2) area of backwater flooding. The area of backwater flooding is here used to include all that portion of the flood plain that inundates through normal processes of flooding. In this sense it includes back-swamp areas, (inter-levee lowlands, rim-swamp, and marginal basin areas), and partially submerged relict natural levees.

Natural Levees

Natural levees of a given stream have the form of more or less ridge-like deposits immediately adjacent to the stream channel. The formation of natural levees is attributed to deposition of the coarser and heavier materials (carried in suspension and as bed load) by a checking of velocity as flood waters leave a definite channel. The height of the levees is in general an indication of the difference in stage level between ordinary floods and low water (Russell, 1936). Similarly, the width and slope of the levees is normally indicative of the size of the stream that formed them, i.e., the wider the natural levee, and the lower the slope, the larger the stream.

The most recent, and highest, levees of the Red River flood plain are those flanking the present day channel. The levees on the western side of the modern river show a better development than those on the eastern side, for they have not been constricted or hampered in their development by proximity to the valley wall. On the west side of the river the levee varies from one-quarter mile to a maximum of three miles in width where modern levees were constructed on relict levees. The average width of the levee is slightly over a mile. Levees on the east side of the river are best developed in the northern portion of Red River

Parish where they reach a maximum width of two miles. South of the middle of the parish the river approaches the valley wall and here the levees diminish in width, the back slopes are steep, and well developed rim-swamp (Russell, 1938) basin areas are numerous.

The levees reach a maximum height of not more than fifteen feet above the back swamp level; the average height is ten feet. The slope from the crest of the Red River natural levees to the back swamp is between three and four feet per mile.

Longitudinally, the average slope of the eastern bank from the Caddo-Red River to the Natchitoches-Red River line is slightly less than 0.4 feet per mile. In the same distance the west bank slopes slightly more than 0.4 feet per mile.

Crevasses

Though no longer active because of the presence of artificial levees, at least seven former active crevasse channels forming a part of the natural levees are known in the area. The upper two of these are known to have been quite active during the time of the "Great Raft"; much of the water diverted from Red River reached the back swamp areas through Tone's Bayou and Bayou La Chute. Howell (1873) and W. H. Harris (1881) report these bayous were active diversion channels as late as 1880. Grand Bayou, Boggy Bayou, Bayou Winsey, Wright Bayou, and Bayou Lumbro served also in this capacity from time to time. Each, at the time of its inception probably fell into the class of raft-head crevasses—crevasses formed at or near the head of the raft as a result of the diversion of waters around the log jam. As the jam moved upstream the crevasse healed to some extent and others had their inception. The channels created during the active lives of the crevasses remained more or less open and today assist in draining the flood plain. The crevasse deposits are easily recognized by their irregular surface and by the extension of the natural levee into the back-swamp. Such deposits may be observed in the vicinity of Lake End, Hanna, Grand Bayou, and Williams.

Back-Water Areas

With each annual rise of the Red River, parts of the floodplain area are usually submerged. This occurs during normal high water stage and need not be accompanied by actual overflow of the river itself. Since the master stream serves as the temporary base level for all tributary streams entering it, any rise in level of the master stream will operate as a dam to raise the stage level of the tributaries. In this way, topographically low areas yearly are inundated and receive a thin deposit of clay and alluvium.

Embraced within the total area of backwater flooding are the backswamps consisting of inter-levee lowlands, rim-swamps and marginal basins, actual former channels of the master stream, and, to some extent, the natural levees associated with these former courses.

The back swamps include all low areas away from the main channel and levees of the stream. The back swamp areas of Red River and DeSoto Parish furnish excellent examples of inter-levee basins, rim-swamps, and marginal basin areas.

Inter-levee lowlands are typically enclosed on all sides by natural levees, relict and modern, and so tend to be elongated and irregular in shape. The lowlands occupy probably the second largest surface area of the flood plain; they are exceeded in area only by the natural levees.

They serve as repositories for the finer sediments carried by flood waters and are normally unsuitable for either agriculture or grazing. Excellent examples of such lowlands are to be seen in the vicinity of and north of Abington, two miles southwest of Grand Bayou, and south of Gahagan between Red Bayou and the Red River.

Rim-swamp, a term proposed by Russell (1938) is applicable to any lowland area flanking the flood plain and abutting against the hills.

In Red River Parish, excellent examples of rim-swamps on the eastern edge of the flood plain are visible along Coushatta and Loggy Bayous in the northern part of the Parish, along Coushatta Bayou in the vicinity of Carroll, Township 13 North, Range 10 West, and along Nicholas Bayou just west of Piermont and Redoak in Township 11 North, Range 9 West. Along the western margin of the valley, equally good examples are to be seen just east and south of Wemple, DeSoto Parish in Township 12 North, Range 11 West, between Red Bayou and the hills southwest of Evelyn, DeSoto Parish, in Townships 11 and 12 North, Range 11 West, and along Wallace Bayou in Township 15 North, Ranges 12 and 13 West (see map, plate IV).

The lower portion of Chemard Lake (Township 11 North, Ranges 10 and 11 West), Dolet Brake and former Dolet Lake (Townships 11 and 12 North, Range 11 West), Crain Lake (Township 11 North, Range 9 West), and Lake Poule d'Eau (Township 11 North, Range 8 West), Natchitoches Parish, are good examples of <u>rim-swamp lakes</u> (see map, plate IV).

Among the better examples of rim-swamp streams in DeSoto Parish are Wallace Bayou and Bayou Pierre River in Townships 13 and 14 North, Range 11 West, and in Township 12 North, Range 11 West, Dolet Bayou in Townships 11 and 12 North, Range 11 West, and Red Bayou and Jims River in Township 11 North, Range 10 West. In Red River Parish, Bayou Nicholas in Township 11 North, Range 9 West, Coushatta Bayou in Township 13 North, Range 10 West, Newman's Bayou in Townships 13 and 14 North, Range 10 West, and Loggy Bayou in Township 14 North, Range 10 West, flank the base of the hills (see map, plate IV).

Marginal Basin

Basins created by alluviation across the lower portions of tributary valleys are considered as "marginal basins". This usage varies somewhat from that of Fisk (1938 A) who used the term to denote a floodplain feature similar to the rim-swamp of Russell.

Bayou Pierre Lake (Township 13 North, Ranges 11 and 12 West), (see fig. 1), the upper parts of Chemard Lake (Township 11 North, Range 11 West), Louie's Brake (Township 11 North, Range 11 West), Bull and Boggy Lakes (Townships 11 North, Range 9 West), and Love Lake (Township 14 North, Range 10 West) are distinctive examples of marginal lakes or wet lowlands in marginal basins (See map).

In conclusion the flood plain consists of an intricate maze of natural levee deposits, crevasse deposits, and back swamp deposits. On the whole it presents the appearance of flatness but its topographic diversity is great enough to permit its subdivision into gently sloping high areas, natural levees, and low, swampy, inter-levee areas. The mutual relationships of these physiographic units supply the necessary evidence for reconstructing the history of floodplain development.

Figure 1. Bayou Pierre Lake bottoms in $SE\frac{1}{4}$, sec. 25, T. 13 N., R. 12 W., DeSoto Parish.

Former Red River Courses

R. J. Russell (1933, 1936, 1938), Fisk (1938A, 1940), and others have shown that individual streams form characteristic meander patterns. They have also pointed out that each stream constructs natural levees whose heights and width are an individual characteristic. The utilization of these criteria in the field supplemented by map observations permitted identification of the relict Red River Courses indicated on the map (Plate III ~~IV~~) and discussed in the following paragraphs.

A relict course and levees of the Red River exists in DeSoto Parish west of Bayou Pierre River in Township 11 North, Ranges 10 and 11 West, and Township 12 North, Ranges 10 and 11 West. Red Bayou, Jims River, Long Lake, and Little Flat River occupy portions of this former course. Near Evelyn in sections 25 and 36, Township 12 North, Range 11 West, and sections 30, 31, and 32, Township 12 North, Range 10 West, Bayou Pierre also occupies a former Red River course.

The rather small Red Bayou channel, which at no known point exceeds twenty-five yards in width, is a clear-cut example of the channel filling and deterioration that occurs once a master stream abandons its course. This course continues southward into Natchitoches Parish as Cow Bayou.

A former Red River course crosses the Red River-Caddo Parish line four miles west of the modern Red River and extends south-southeast, then south to the vicinity of the Bayou Pierre Lake Basin. From the parish line southward to the junction of this course with Bayou Pierre River, the channel is occupied by Prairie River. South of the junction for about one and one-half miles, it is occupied by Bayou Pierre River. The course then meanders eastward, turns south, and swings westward into the

Bayou Pierre Lake Basin where it ascribes a large meander through the lowland to emerge from the south side of the basin about three miles slightly northwest of the village of Grand Bayou. This meandering course twice crosses that of Bayou Pierre River, emerges from the basin, wanders south and east, and eventually disappears in the back-swamp area west of Gahagan. A probable southern continuation of this course is now occupied by Bull Bayou, Bayou Pierre River, and Horseshoe Bayou.

A course older than this Prairie River-Boggy Bayou course, and its undetermined exact continuation southward, is observable between it and the Red River. This course, the Abington, may be found on the north side of former Cannisnia Lake where its levees form a part of the alluvial dam surrounding this basin. From here the course extends eastward across Bayou Pierre, then swings southward to cross the Texas and Pacific Railroad at Abington. Westward, its levees make up the eastern alluvial dam enclosing the Bayou Pierre Lake Basin. Below Abington the course passes through Gahagan and Armistead, swinging south and west to again cross the Pierre River course to a junction with the Red Bayou course.

Excepting discontinuous sets of levees on the flood plain, these three relict courses, the Red Bayou, the Prairie River-Boggy Bayou, and the Abington courses constitute the only evidences of channel changes thus far identified west of the present course of the Red River.

The modern Red River flows close to the eastern valley wall and only a few relict channels are found east of it. Loggy Bayou, from the vicinity of Lake Bisteneau southward to its debouchment into the river some two miles northwest of East Point, occupies a relict channel of the Red River. Coushatta Bayou, which branches off Loggy Bayou in section 17, Township 14 North, Range 10 West, and empties its waters into the Red River about one-half mile above the Highway bridge at Coushatta was a contemporary course. Government surveys prior to and during 1850 show Red River as occupying the channel now followed by Coushatta Bayou below Carroll station. Another recently abandoned channel can be seen west of the villages of Crichton and Hope in Township 13 North, Ranges 10 and 11 West. Crichton Lake, section 6, Township 13 North, Range 10 West, remains as evidence of this former channel position. Bayou Nicholas, now closed off from the main Red River Channel as a measure of flood protection for the town of Coushatta, carried a considerable volume of water during stages of the "Raft" in this vicinity. Occasional ox-bow lakes also attest the presence of the Red River east of its modern position. Notable among these is the now dry channel around Porter's Island (sections 15 and 49, Township 11 North, Range 9 West). As late as 1848 this "island" was west of the Red River; today it lies east of the river and is being rapidly destroyed where the river impinges against its west side.

Rafting

Many writers have reviewed the development and removal of the Red River raft and the processes operative during its existence.

Briefly, the raft is believed by Veatch (1906 A) to have started as a great log jam in the vicinity of Alexandria and to have rapidly worked upstream by accretion of logs and sediments. The effect of this log jam was to divert the waters of the Red River into many channels. Before the final removal of the raft in 1873, the Red River channel was constantly shifting and offered many difficulties to river navigation.

In DeSoto and Red River Parishes the effects of rafting were very pronounced.

The Red River was diverted around the raft in the vicinity of southern Caddo and of Red River Parish and much of its volume followed the Bayou Pierre River channel. W. H. Harris (1881) reports:

> "The waters of the Red River leaving the main channel of that stream below the town of Shreveport, through the Bayou Pierre and the Tones Bayou, make a chain of lakes, forming the eastern boundary of this (DeSoto) parish, and again discharge themselves by the Bayou Wimsey, into the Red River, in a very deep channel below the town of Coushatta.
>
> Steamers, during the boating season thus came up within nine miles of Mansfield, entering the Wimsey at its Red River mouth, thus giving us good steamer navigation for about six months of the year."

Additional exits of water from the main Red Channel around the raft were reported to have been Bayou La Chute, Grand Bayou, and Boggy Bayou. In particular, Bayou Nicholas, near Coushatta, seems to have served in the capacity of a large outlet.

The most important effect of the raft removal was the restriction of the Red River waters to a single channel. This caused the disappearance of diverted waters from the back swamp areas and the temporarily higher base level of these areas was destroyed. In consequence the lake areas drained and the streams flowing through these basins locally began the task of downcutting through the alluvium that had been deposited there. This downcutting was restricted to the lower tributary valley areas where rapid sedimentation had occurred. In other places, the lengthening of stream courses and decreased gradients associated with the draining of lakes caused alluviation. The deposits of alluvium filling the lower ends of the smaller tributary streams of this area attest to the activity of these processes.

Black Lake Bayou Alluvial Valley

Black Lake Bayou, the largest tributary stream in DeSoto or Red River Parish, rises in southwestern Claiborne Parish where it is known as Crow's Creek. It then flows south and a little west through Webster Parish, into and across Bienville Parish, forming the eastern boundary line between Red River and Bienville Parishes, and the northern half of the Red River-Natchitoches Parish boundary before flowing into Natchitoches Parish and thence into Red River.

In its Red River Parish area, the flood plain of Black Lake Bayou slopes almost one foot per mile. Its width varies from one-half mile to almost two miles.

The entire flood plain of Black Lake Bayou is subject to frequent flooding from rains. Several times during the summer field season of 1940, the bottom was almost completely inundated by high water resulting from rains in the immediate area and to the north of the parish. At no place did the writer observe restriction of the Black Lake Bayou waters to a single channel. They flowed through branchwork patterns, abandoned channels, and ox-bow lakes.

Big Clear Lake in sections 35 and 36, Township 13 North, Range 8 West, is an excellent example of an ox-bow lake, and the channel extending southwest from it is an equally good example of an abandoned channel. Numerous other relict channels and ox-bows are visible on aerial photographs covering the area.

The lower portion of Black Lake Bayou flood plain adjacent to Red River Parish is swampy and more or less permanently covered by the impounded waters known as Black Lake. The lower portion of this bayou in Red River Parish is characterized by three large arcuate "bends" that have no relationship to meandering. The radius of these "bends" approximates one and one-half to two miles. Neither their significance nor origin is understood but they are clearly anomalous patterns. Secondary meanders with a radius of less than one-half mile are well developed on these "bends".

The valley is broad and flat-bottomed and little of the bottom land is used for agriculture because of its susceptibility to overflow. Valley walls are relatively gentle in most places, but locally the flood-plain escarpment is abrupt. At some places a maximum relief of seventy-five feet within less than a quarter mile of the bottom is attained.

The bayou drains an area of about seventy-five square miles in Red River Parish. Its flood plain has an area of almost twenty square miles. The largest tributaries entering it from Red River Parish are Grand Bayou, Brushy Creek, Liberty Creek, and Indian Creek.

The Sabine River and Flood Plain

The Sabine River, originally called Rio Sabinas (Belisle, 1912) heads in northeast Texas in Collin, Hunt, and Rockwall counties. It flows southeastward to near Logansport, Louisiana, from which point to Sabine Lake it forms the boundary between Texas and Louisiana. In DeSoto Parish it maintains a width of from fifty to one hundred feet at low water stage.

From its first contact with Louisiana (section 30, Township 12 North, Range 16 West) to Hadden's Bend (one and one-half miles upstream from Logansport) the river meanders in a flood plain normally two miles or more in width. From Hadden's Bend to approximately four miles downstream from Logansport, the river is essentially straight. The flood plain is less than one-quarter of a mile wide. Below this reach it meanders fortuitously about in a three-mile wide flood plain until it leaves the parish in section 14, Township 10 North, Range 15 West.

Profiles of the Sabine River issued by the U. S. Engineers Office at Galveston, Texas, in 1940 show the river slope, bottom slope, and average bank slope of the river from the DeSoto Parish-Panola County line to the DeSoto-Sabine Parish line:

High Water ------------- 0.6 foot per mile

Average Bank ----------- 0.6 foot per mile

Stream Bed ------------- 0.68 foot per mile

Across the very top of the Logansport structure (see plate VII) in the vicinity of Logansport, the high water and average bank slope rise to slightly more than one foot per mile. In this same distance the stream bed slope attains a maximum slope of two feet per mile.

At Logansport, adjacent to the river, the bluffs attain a maximum height of sixty-five feet above extreme low water stage. This is the greatest recorded difference in bank top and water level throughout the DeSoto Parish portion of the course. Both up and downstream from Logansport, the average difference in height of the water surface (extreme low water in summer of 1939) and the adjacent floodplain banks is between thirty and forty feet. Where the river strikes the hills or Pleistocene terraces bordering the valley, bluffs of greater height are formed.

The absence of detailed maps of the river and of its flood plain necessarily renders difficult any study of channel changes and of detailed physiography. Aerial photographs reveal the presence of several ox-bow lakes and abandoned channels. Foot traverses, and automobile traverses along the few passable roads, disclose numerous abandoned channels and indicate that, in general, the floodplain surface is quite irregular. Few conspicuous levees were observed in the floodplain area of DeSoto Parish, but this is probably due to the extremely thick growth of vegetation covering seventy-five per cent or more of the total floodplain area.

The maximum relief measured on the Sabine River flood plain amounts to slightly more than twenty feet, and this represents the difference between the bottoms of partially filled relict Sabine courses and the adjacent bank crests. Where observed, the maximum relief between the back swamp and the natural levee crests amounts to about fifteen feet.

The strongly meandering course above and below the "Logansport Reach" is attributed to the effective differences in stage level of the river which involves a ratio between the actual stage difference and the volume of water in a channel (Russell, 1936). With a maximum stage difference of about forty feet and comparatively small low-water volumes, a highly tortuous course is to be expected in those regions where structural control does not actually hinder or prevent the development of meandering.

The relatively straight and narrow course of the Sabine River in the vicinity of Logansport (in this report called the "Logansport Reach") reflects the control exerted upon the river by the Logansport structure. Reference to the accompanying subsurface map (Plate VII) of DeSoto Parish shows the river in this portion of its course to be flowing across the western part of an elongate east-west anticline. Anomalous elevations and slopes on the Montgomery terrace surface slightly east of the town indicate that this anticline has risen to some extent since the middle of the Pleistocene. Here, a maximum elevation of two hundred and forty feet (Paulin altimeter) is attained. To the south the maximum elevations on the same surface decrease in one mile to two hundred and twenty feet, a slope of twenty feet per mile. The extreme maximum normal slope obtained elsewhere is less than ten feet per mile downstream. To the north, the elevations similarly decrease, whereas, under normal conditions they should rise. Thus a surface profile drawn North-South across the Logansport structure on top of the Montgomery terrace surface is warped in conformity with the structure below. Similar anomalous slopes and elevations are encountered on the Prairie terrace surface; but, because of its absence in DeSoto Parish north of Logansport, it can only be used as circumstantial evidence in favor of post-Pleistocene (post-Prairie) uplift of the structure. With this point admitted, it becomes established that the Sabine River in its concomitant course across the Logansport structure is antecedent. It seems impossible to assign any other origin to this portion of the course than that during late Pleistocene times, the Sabine River assumed its present position in the vicinity of Logansport. Subsequent to that time uplift of the Logansport structure continued with entrenchment of the channel in its course across the structure. Relative to normal stream action, entrenchment has been or was rapid enough to prevent meandering. A careful examination of the Prairie terrace surface from Logansport west to the hills in Texas revealed no recent course of the Sabine other than that now occupied.

From about a mile below Logansport upstream to the DeSoto Parish-Panola County line the Sabine River occupies the position of a rim-swamp stream on the Prairie terrace surface.

Shoals

At numerous places above and below Logansport, shoals are present in the river. The writer traversed most of the river during extreme low water periods in 1939 and 1940. The seven shoals upstream from Logansport to Texas, are formed mainly by reddish-brown, ferruginous, lignitic sands that are surficially indurated. Locally, glauconite is interspersed with the sands. Interbedded dark gray to purplish-brown lignitic clays and silts with a high mica content are also exposed. The shoals probably represent a single outcrop, separated by reaches on easily eroded beds, of the Cow Bayou and Dolet Hills members of the Logansport formation (see pp.

Below Logansport to the Sabine Parish line two shoals are known. These are at "The Rocks" and at Sandy Point, both in section 3, Township 10 North, Range 15 West. Large calcareous concretions and septarians in matrices of dark gray lignitic silts and clays form resistent outcrops at these places.

PLEISTOCENE TERRACES

Introduction

The principal work on terraces in Louisiana has been done by Fisk, who, in 1938, applied the names Williana, Bentley, Montgomery, and Prairie to sucessively younger Pleistocene terrace surfaces differentiated in Grant and La Salle Parishes in central Louisiana. Subsequently, Fisk (1939, 1940), Huner (1939), Rukas (Personal communication), R. D. Russell (Personal communication), Welch (Bulletin 22, Louisiana Geological Survey), and Woodward (1941) have mapped the surfaces over much of Louisiana. The position of the terraces up the Calcasieu, Mississippi, Ouachita, Red, Sabine, and other rivers of Louisiana is now known. The writer assisted in the field work in central and western Louisiana and was able to trace the surfaces directly into the DeSoto-Red River Parish area.

The terrace surfaces are but the upper surfaces of sedimentary formations. A more complete discussion of the formations may be found on page 175. A brief summary of the necessary information for understanding the origin and distribution of the terraces is, however, included here.

Core holes through the terrace deposits in both DeSoto and Red River Parishes substantiate the thesis (Fisk, 1938, 1939, 1940) that each terrace surface is underlain by a definite sequential series of sediments, grading from coarse sands and silts at the base into silts and clays at the upper surface. Field examination along escarpments between terrace surfaces supplies additional evidence, for here, in the epeirogenic region of Fisk (1939 B), uplift has been great enough at most places to expose the entire terrace sequence and the underlying Tertiary sediments. A reasonable method of formation and the Pleistocene age of the terraces has been indicated by Fisk (1938 A, B, 1939 B, 1940). Essentially this mode of origin is based upon cyclic eustatic changes of sea level during the Pleistocene, accompanied by isostatic uplift of the continental areas, especially in the vicinity of regions of heavy sedimentation. Valleys cut during low sea-level glacial stages filled with alluvium during the rising sea levels leading to interglacial times. With the decreased stream gradients accompanying the higher sea levels of interglacial times, the load capacity of the streams was accordingly decreased so that finer and finer materials were successively deposited. The sedimentary sequence consists then of basal gravel lentils in a sand matrix deposited by the overloaded, anastomozing streams as glaciers started to wane. Upward through the sequence, sands, silts, and clays are found with fine materials predominant toward the end of each stage of alluviation.

Slight uplift accompanied each cycle of cutting and filling and prevented the successive alluvial surfaces from attaining the level of its predecessor. The alluvial terraces have been traced from the Gulf of Mexico inland for hundreds of miles along major streams with similar elevations recorded on opposite sides of the individual valleys.

The terrace surfaces are alluvial terrace surfaces because they represent the upper surface of a definite depositional unit. As elsewhere in Louisiana, terrace surfaces of local development are present along the Red River and its major tributaries in DeSoto and Red River Parishes. These are believed to be associated with shifting positions of the largest river courses.

<u>Structural Distinctions:</u> A distinguishing factor employed in field mapping of the terrace surfaces in areas to the south in central Louisiana is the criterion of downstream slope of the surface. In contrast to the varying surface slopes observed in central Louisiana, the surfaces in northwestern Louisiana are largely out of reach of the tilting effects due to sedimentary downdrag in the geosynclinal area to the south. The slopes here are quite uniform, a fact that indicates the terrace surfaces of the DeSoto-Red River Parish area are located in the epeirogenic region (zone of isostatic uplift) proposed by Fisk (1939 B, 1940). It is necessary to bear in mind that the slopes here, as elsewhere, vary inversely with the size of the parent stream.

The average slopes of the terrace surfaces observed along the major streams in DeSoto and Red River Parishes are, in feet per mile:

	Red River	Sabine River	Black Lake Bayou	Grand Bayou
Prairie terrace	0.75-1.0	1.0	1.5	2.0
Montgomery terrace	1.0-1.5	1.5	1.75	---
Bentley terrace	2.0	2.1	2.0-2.5	---
Williana terrace	---	---	---	---

<u>Lithologic Distinctions:</u> The terrace materials of DeSoto and Red River Parishes are separable into two main groups on the basis of their ultimate origin. The Red River sediments were derived principally from the "Red Beds" of the Permian Basin area of north Texas and south Oklahoma. Sediments deposited by tributaries of the Red River were derived chiefly from Cenozoic deposits of Louisiana. In contrast to the typically purplish-red hue of the Red River deposits, those of the Red River tributaries are characteristically gray or brown in color. The Sabine

River terrace deposits were derived from Cenozoic and Cretaceous outcrop areas, those of its tributaries in DeSoto Parish from Cenozoic deposits alone. The Sabine River sediments of Prairie and Montgomery age are normally gray or brown in color, but may be red-brown; the older, more highly oxidized terrace deposits, are brownish or purplish-red in color. Deposits of the Sabine tributaries are also gray or brown in color.

Though terraces belonging to separate stream systems may in most cases be recognized and separated on a lithologic basis, it is normally impossible to separate the Williana, Bentley, Montgomery, and Prairie sediments on the basis of such criteria. There are, however, certain useful distinquishing features that may be employed circumstantially. Older materials are, in general, more highly oxidized. Williana and Bentley sediments on outcrops usually possess a purplish-red color which results from a coating of iron oxide on the individual grains and is concentrated near the outcrop surface. Normally this secondary oxidation color is not present on deposits of Montgomery and Prairie age. The constant passage of ground waters through porous materials at the base of older deposits effects a unifying influence by removing or masking some of the original sedimentary structures. Within a few inches of the surface, and, in certain cases, to measured depths of at least three feet, cycles of solution and deposition have left a structureless mass of gravel, sand, silt, and clay.

Soils Distinctions: Soils technicians of the United States Department of Agriculture have developed a classification for terrace soils, that, in respect to terraces younger than Bentley in age, has proven invaluable in separating terrace from Tertiary materials. Because of their greater dissection and soil profile development, the soils developed on the older terraces are included within the realm of upland (Tertiary soils in DeSoto and Red River Parishes) soils by these men. However, certain of these upland soils (as the Ruston) seem to be restricted to the older terrace deposits and are useful for differentiating the older from younger terraces.

<u>Topographic Distinctions</u>: Under this heading must be considered the criteria of topographic position, differences in elevation of the terrace surfaces, and variations in dissection. In order from oldest to youngest, the Williana, Bentley, Montgomery, and Prairie terrace surfaces occupy successively lower topographic positions. Logically, each successive younger terrace, in its normal position, lies closer to the level of its parent stream. The intervals separating successive terrace levels of the larger streams of this area are:

Interval Between	Red River	Sabine River	Black Lake Bayou
Flood plain-Prairie terrace	25-30'	25-30'	20-25'
Prairie terrace-Montgomery terrace	30-40'	30-40'	30-40'
Montgomery terrace-Bentley terrace	50-75'	50-60'	----
Bentley terrace-Williana terrace	----	----	----

The older surfaces are more highly dissected because of their higher topographic position and because they have been subjected to more Quaternary erosion. The Prairie surface is characterized by flat divide areas and entrenched streams. The Montgomery topography is generally rolling with a few flat divides, while the Bentley consists of isolated remnants or belts with the original surface rarely preserved. At no place in this area is the original Williana surface exposed.

As presented by Fisk (1940), two main drainage criteria are usable in differentiating terrace surfaces. Of these, the restriction of certain tributary systems to an individual surface often furnishes a valuable criterion for differentiation. Rim-swamp streams frequently serve to mark the exact inner edge of a terrace (the escarpmental base of higher terraces or of Tertiary hills), but normally indicate only the approximate contact. However, in DeSoto and Red River Parishes, the spotty occurrence of the greater portion of the terrace deposits makes the first criterion of little use except in mapping the widespread Montgomery surface of Red River Parish. Rim-swamp streams as Grand Bayou (Red River Parish) and Vacherie Bayou (DeSoto Parish) are excellent examples of streams which mark the inner edge of terrace surfaces.

Terraces in DeSoto and Red River Parishes

The writer has applied the terrace names proposed by Fisk (1938) to terraces in DeSoto and Red River Parishes after determining their equivalence by field studies. The extent of each Pleistocene surface and the deposits underlying them is shown on the geologic map. The inaccessibility of some areas, coupled with the time available for field work, necessitated a certain amount of generalization of the terrace limits. The terrace limits as used here mark essentially the contact of the depositional sequence underlying the terrace surface with older sediments and do not necessarily indicate the original extent of the terrace surface.

Prairie Terrace

With its surface separated from the recent alluvium surface by an interval of 25-30 feet, the Prairie constitutes the lowest alluvial Pleistocene surface of DeSoto and Red River Parishes. Lying closely adjacent to the parent stream, its surfaces flank the major rivers and extend upstream along many of their affluents even in the manner of existing alluvium.

Initial relief on the surface probably attained a maximum of ten feet, or slightly more, between the back swamp and the natural levee crests. Existing relief does not greatly exceed this figure in most cases.

The few streams draining the surfaces have an initially developed dendritic pattern consequent on the original surface. This is particularly true of the escarpmental consequents that have cut into the surface for some distance. Insufficient time has elapsed for a great amount of dissection of this surface in most areas.

Red River Prairie Terrace Remnants of DeSoto and Red River Parishes

The surface area of the Prairie terrace of Red River origin in Red River Parish is little more than one square mile; in DeSoto Parish it includes an area of about fifty square miles. The surface is relatively flat; dissection is prevalent only near the escarpmental edges and adjacent to the few larger streams flanking or flowing upon the surface.

In Red River Parish, three small separate areas of the Red River Prairie terrace surface are known. The first, in sections 5 and 6, Township 14 North, Range 10 West, may be observed from U. S. Highway 71 near the Bienville-Bossier-Red River Boundary confluence. The second surface remnant lies atop Paps Hill, a floodplain surrounded "island", in section 33, Township 13 North, Range 11 West (see fig. 2). The third occurs in sections 13 and 24, Township 11 North, Range 9 West, and may

Figure 2. Escarpment between Prairie terrace and flood plain on north side of Paps Hill in sec. 33, T. 13 N., R. 11 W., Red River Parish.

be observed where Louisiana Highway 248 crosses the Natchitoches-Red River Boundary.

The Prairie surface in DeSoto Parish extends from the vicinity of Frierson southeastward to the Bayou Pierre Lake Basin. Bayou Pierre River approximately marks its eastern boundary. The northernmost boundary of this surface is near Louisiana Highway 145 northeast of Frierson. From Frierson the westward edge swings upstream along Vacherie Bayou, then southeastward and upstream along Fordoche and Na Bonchass Bayous. The surface is found flanking the west and south shores of Clear and Smithport Lakes. Portions of the same surface also flank Mundy and Clifton Bayous. In the vicinity of Rambin store, two and one-half miles south of Evelyn, a badly dissected remnant of the surface is known. Other small remnants of the surface are exposed around the valley mouth of Wallace Bayou.

<u>Difficulties in Mapping</u>: At most places, the break between the inner edge of the Prairie terrace and the Tertiary hills is gentle and difficult to delineate. In the vicinity of Frierson and northeast of that town, the underlying Tertiary sediments closely approach the Prairie terrace surface as attested by islands (Cow Bayou member of the Logansport formation) which project through the Prairie surface (see geologic map, plate I). The difference in slope between the Prairie surface and the underlying Tertiary surface is so slight that a change of five feet in elevation may mean the difference between Pleistocene and Tertiary. In such areas mapping must be based largely on soil and botanical differences checked by numerous bore holes and references to elevations.

Interfingering of the Red River sediments with the Midway derived deposits of Vacherie, Fordoche, and Na Bonchass Bayous takes place approximately along a northeast-southwest line parallel to Vacherie Bayou.

Here it is difficult to delineate the two sedimentary facies of terrace materials.

Sabine River Prairie Terrace Remnants of DeSoto Parish

Sabine River terrace remnants of Prairie age in DeSoto Parish are restricted to a belt bordering the river between Logansport and the Sabine Parish line. The remnants occupy a total area of approximately fifteen square miles; individual segments average less than four square miles in area. They are situated between such southwest-flowing tributaries of the Sabine River as have maintained approximately their present courses since some time during the early Wisconsin.

The best preserved Prairie terrace remnants are situated between Logansport and Clement Bayou. They are visible along Louisiana Highway 143 in Township 11 North, Ranges 15 and 16 West. The surface here is quite well preserved (see fig. 3) and, but for the extremely large pimple mounds dotting the surface, has a maximum relief away from the larger streams of less than ten feet. Castor and Grand Cane Bayous flow across this surface in well entrenched channels. The entrenchment of the Castor Bayou channel is particularly prominent. In that portion of its course due east of Logansport, Castor occupies a deep, straight-walled meandering channel in the Prairie deposits. The meandering course is apparently inherited from an original Pleistocene pattern but its entrenchment has occurred in Recent times. The Prairie surface slopes abnormally only in its northernmost portion southeast of Logansport where it lies on the south flank of the Logansport anticline. Here the slope is apparently as great as 2.5 feet per mile.

Prairie terrace remnants are present as upstream continuations

Figure 3. NW view across Prairie terrace surface SE of Logansport in sec. 13, T. 11 N., R. 16 W., DeSoto Parish.

of the Sabine River surface along the larger Sabine tributaries of DeSoto Parish. Remnants occur flanking Castor Bayou upstream to the vicinity of Longstreet, along Grand Cane Bayou almost to the town of the same name, along the Clement-William's Bayou system to its crossing of U. S. Highway 84 southwest of Logansport, and up Cow Bayou to its crossing of Louisiana Highway 747. In total area these remnants do not exceed twenty-five square miles.

In general, the surfaces are flat and relatively undissected, especially those adjacent to Cow and Grand Cane Bayous. Large pimple mounds break the inherent flatness of the surfaces. They are particularly prevalent and large on the surfaces bordering Grand Cane Bayou. Escarpments bordering the terraces downstream are, in general, rather steep and range up to thirty feet in height. Upstream the terrace surfaces merge with the present day flood plain and differentiation of the two becomes impossible.

The average downstream slope of the Castor and Bushneck Bayou Prairie terrace surfaces is slightly more than five feet per mile, of the Grand Cane Bayou surface about four and one-half feet per mile, of the Clement-William's Bayou surface almost seven feet per mile, and of the Cow Bayou surface slightly less than four feet per mile.

Grand and Black Lake Bayou Prairie Terrace of Red River Parish

The largest area of Prairie terrace remnants of Black Lake Bayou-Grand Bayou origin is situated near the confluence of Grand and Black Lake Bayous. The surface is badly dissected and covers a total area of slightly more than ten square miles. Scattered continuations of this same surface extend upstream along both Grand and Black Lake Bayous into

Bienville Parish. The interval between the Prairie and recent surfaces decreases from an average of twenty-five feet to an average of fifteen feet from the southeastern corner of Red River Parish upstream to the Bienville Parish line. The Grand Bayou surface, in the same distance, slopes downstream at an average rate of two feet per mile, the Black Lake Bayou surface at an average rate of one and one-half feet per mile.

Montgomery Terrace

The Montgomery terrace surface remnants cover a greater area than the Prairie, Bentley, or Williana surfaces in DeSoto and Red River Parishes.

One remnant of the Montgomery surface of Red River origin is preserved west of the river. This remnant caps the southern three-fifths of Couchandra Hill (Township 12 North, Range 10 West) and is highly dissected. East of the river, the Montgomery surface of Red River origin occupies an area of sixty-five square miles in a belt bordering the Red River alluvial valley. It increases in width from about one mile in the northern portion of the parish to over five miles along the Red River-Natchitoches Parish line. The surface is well dissected and retains some of its original flatness only in its widest part beween Coushatta and the Natchitoches boundary. Numerous streams have carved the western escarpment into a maze of hills and ravines.

As the Red River Montgomery surface swings southeastward into Natchitoches Parish, it widens and flattens considerably. This widening can in part be attributed to the original greater width of the Montgomery flood plain near the confluence of the Red River and Black Lake Bayou flood plains.

From the Bienville Parish line southward to Grand Bayou, a continuous belt of Montgomery flanks the west side of the Grand Bayou flood plain. Remnants of the Grand Bayou Prairie terrace surface locally separate the Montgomery terrace from the Recent flood plain. The Montgomery surface here covers an area of approximately thirty square miles, and it is separated from the Recent flood plain by an interval of about sixty feet, from the Prairie surface by about thirty-five feet. Streams working headward have almost completely destroyed exposed remnants of the original Montgomery surface.

Other streams have progressed headward in the past into the higher Bentley deposits to the west and have constructed alluvial cones of Bentley debris on the Montgomery surface. These masses of sand and gravel exert a significant control upon drainage, in addition to complicating the mapping of the terraces on the basis of elevations of the lower alluvial surface. Alluvial cones extending eastward from the Bentley deposits are particularly prominent in section 31, Township 14 North, Range 8 West, section 36, Township 14 North, Range 9 West, sections 5, 6, 7, and 8, Township 13 North, Range 8 West, and section 1, Township 13 North, Range 9 West. Not only are the cones marked by obvious increases of surface elevation, but they are manifested in the anomalous courses of Black Lake Bayou tributaries (see geologic map, plate II). The tributaries are diverted to the north and south around the cones rather than maintaining essentially direct courses to Black Lake Bayou as is the case with other tributaries. In areas dominated by alluvial cones, differentiation of the surfaces must be made on the elevations of the Tertiary-terrace contacts.

In DeSoto Parish the southern portion of an extensive Montgomery surface of Sabine River origin extends from south of Logansport northwestward parallel to the river to the Panola County, Texas, line. This surface can be traced for more than ten miles into Texas as a flat, almost featureless physiographic feature, interrupted locally by profuse pimple mounds. The surface covers an area of slightly less than fifteen square miles in DeSoto Parish and is upwarped over the Logansport anticline. The Montgomery surface has an elevation of two hundred and twenty feet two miles southeast of the center of Logansport. The terrace due east of the town has an elevation of two hundred and forty feet; two miles north-northwest of town the elevation is two hundred and thirty feet. This upbowing of the surface indicates marked post-Montgomery uplift along the Logansport anticline.

From elevations obtained in Texas (Panola County) and in DeSoto Parish, the computed downstream slope of the surface northwest of Logansport is one and one-half feet per mile.

Bentley Terrace

In DeSoto and Red River Parishes the Bentley terrace has a total outcrop area less than that of either the Prairie or Montgomery surfaces. The Red River Bentley surface is entirely restricted to Red River Parish where it outcrops in two belts: one parallel to the flood plain of the Red River, the other parallel to the Black Lake Bayou flood plain. The belt parallel to the Red River consists of isolated remnants of a once continuous surface (see fig. 4). Nowhere in this belt is the original surface preserved.

The belt parallel to Black Lake Bayou extends from near the center of the north line of Township 14 North, Range 9 West, southward along Louisiana Highways 90 and 99½ east of Hall Summit, then angles

Figure 4. South view from Bentley terrace surface along U. S. Highway 71 in sec. 8, T. 14 N., R. 10 W., Red River Parish. The Montgomery terrace surface bordering Love Lake appears as a topographic low between the camera and the Bentley surface in the background.

southeastward to its termination by the Black Lake and Grand Bayou drainages in Township 12 North, Range 8 West. Little of the original surface is retained although the dissected surface extends continuously throughout this distance. Arcuate scallops in the Bentley scarp record stream impingement against the valley wall. Though somewhat masked by dissection and alluviation along the escarpments, the scallops retain enough of their original outline to suggest formation by an ancestral Black Lake Bayou comparable in size to the existing Red River.

Residual gravels on the Tertiary outcrop area of central Red River Parish indicate that this area was originally covered by Bentley deposits. Of equal importance to the residual gravels, as an indication of the former existence of the Bentley surface and underlying deposits, are residual hills of basal Bentley sands and gravels. Though these remnants nowhere approach the original top surface of the Bentley, the elevation of the contacts of the basal gravels and Tertiary sediments corresponds to that obtained in nearby areas where the original Bentley surface is present. Most of the remnants cover but an acre or two and have not been included on the geologic map; those large enough to be shown with some degree of accuracy are to be seen in section 2, Township 14 North, Range 10 West, section 7, Township 14 North, Range 9 West, and section 32, Township 13 North, Range 9 West.

The Bentley terrace surface in DeSoto Parish is present only as a series of remnants along the valley of the Sabine River. The following are some of the more important parts of the original Bentley surface preserved in DeSoto Parish: (1) two miles northwest of Hunter along Louisiana Highway 143 in section 26, Township 11 North, Range 15 West, and, (2) west and northwest of Oak Grove in sections 8, 16, and 17, Township 11 North, Range 15 West.

Residual gravels in the soils east of the present outcrop area of the Bentley terrace suggests that the Bentley deposits formerly extended over this area. Some doubt exists, however, as to the exact age of these gravels. It is entirely possible that they are residual from the higher Williana deposits now almost entirely removed by erosion.

Williana Terrace

A single remnant covering an area of about twenty-five acres stands one mile north-northwest of Hunter as evidence of the former existence of a Sabine River Williana terrace surface in DeSoto Parish. The original surface level is completely destroyed but elevations of the contact of the basal gravels and sands with Tertiary sediments definitely show that the Williana terrace once covered this area. The top surface of the Bentley terrace here attains a maximum elevation of two hundred and ninety feet while the basal elevation of this deposit is three hundred and sixty feet. As mentioned under the discussion of the Bentley terrace, the presence of numerous residual gravel in a belt northeast of and parallel to the present outcrop area of the Sabine River Bentley terrace surface may also point to the former existence of Williana terrace materials over this area.

Pleistocene Courses of Red River

A study of the occurrence of Pleistocene terrace surfaces and underlying deposits permits the approximate location of pre-Recent courses of the larger streams and rivers during the Pleistocene to be determined. Remnants of the Red River Williana terrace surface have been traced by members of the Louisiana Geological Survey from southwest Arkansas across eastern Webster and western Claiborne Parishes, central Bienville Parish, northeast Natchitoches Parish, southwest Winn Parish, and central Grant Parish, into northern and western Rapides Parish. This belt marks the Williana course of the Red River and no Red River terrace deposits of this age are found to the west of it. Red River Williana sediments are absent west of a roughly arcuate line through Shongaloo, Sibley, King's Dome, Coochie Brake Dome, and Colfax. The Red River deltaic plain of Williana times is exposed northwest of Alexandria, Rapides Parish, (Fisk, 1940).

The Bentley course of the Red River lies west of and roughly parallel to the Williana course. The widespread Bentley surface in south central Webster Parish, in western Bienville Parish, in eastern Red River Parish, in southwestern Winn Parish, and in western Grant Parish, make delineation of the Bentley flood plain comparatively simple. No Red River Bentley surfaces are known to exist east of the Red River Williana surface. On the basis of this evidence the Bentley course of the Red River crossed northeastern Bossier or northwestern Webster Parish, southern Webster, western Bienville, central and eastern Red River, northeastern Natchitoches, southwestern Winn, and western Grant Parishes, and crossed the area corresponding to its present course somewhere in the vicinity of Alexandria.

The Red River shifted westward again in Montgomery times. It crossed central and eastern Bossier Parish, southwestern Webster and western Bienville Parishes, west central Red River Parish, north central Natchitoches Parish, southwestern Bienville Parish, western Grant Parish, and Rapides Parish as affirmed by the presence of widespread Montgomery surfaces in these areas. This course presumably crossed its modern course in the vicinity of Colfax.

During Prairie alluviation, the Red River, upstream of the present Natchitoches-Red River Parish boundary, was largely restricted to a valley west of its modern one. The broad belt of Prairie deposits extending from the Arkansas-Louisiana-Texas corner to central DeSoto Parish clearly shows the position of the Red River flood plain during the Prairie times. Prairie terrace surfaces in Bossier and Bienville Parishes probably are remnants of the extreme eastern part of this former floodplain surface of the Red River. Between the Bayou Pierre Lake Basin in DeSoto and Red River Parishes and the Natchitoches-Red River Parish line west of Grappe's Bluff, the Prairie course crossed the area of the present Red River alluvial valley. A single "floodplain-island" capped by terrace remains as evidence. This surface is picked up just west of Grappe's Bluff and extends to the vicinity of Campti. Downstream from Campti the Prairie and Recent courses of the Red River are approximately analogous.

In résumé, it appears there has been a progressive westward shift in the position of the Red River from Williana through Prairie times. During the last interglacial stage the river reversed its westward movement in northern Louisiana (above Coushatta, Red River Parish) and migrated eastward. That portion below Campti has remained in essentially its same position since Montgomery times.

Recent Alluvial Surfaces

The Red River has recently (pre-present time) trenched its flood plain so that during normal flood the older levees stand ten to fifteen feet above high water (Fig. 5). The two levels of the flood plain are

Figures 5, 7, 8, 9, 10, 11, 12, 13, 14, 23, and 32 (see pocket).

visible at Coushatta, along Grand Bayou where Louisiana Highways 9 and 90 cross the flood plain, and along Black Lake Bayou in the southeastern part of Red River Parish. Rather large pimple mounds locally dot the upper flood plain, and, in most places but little dissection has occurred. The surface at Coushatta is not known to flood and those surfaces bordering Grand and Black Lake Bayous reportedly overflow only in years of unusually heavy rains as in the summer of 1927. This surface has been mapped continuously for about three miles in the vicinity of Coushatta and has been observed at other places in the parish, both upstream and downstream from the town. A similar and probably equivalent surface is exposed at Campti (Natchitoches Parish), and can be traced southward into Grant and Rapides Parishes where Fisk (1938, 1941) explains their presence on the assumption that a shortening with associated gradient increase occurred when the Red River shifted north through the Avoyelles Hills.

Mounds

"Natural" mounds (see fig. 6), occurring as more or less circular hillocks of earth, exist indiscrimately on Quaternary and Tertiary deposits alike in DeSoto and Red River Parishes. The origin and to some extent, the distribution, have been discussed by numerous writers within the last few years. Melton (1929) summarized and presented evidence for and against the various theories of origin existent at that time. He attributed the mounds to gullying by small streams and rivulets in a weak, sandy soil. Rich (1934) opposed Melton on this mode of genesis and suggested that the mounds were due either directly or indirectly to bunch vegetation in a transition zone between prairie and forest. Fisk (1938 A) added nothing to the ideas concerning origin of mounds but listed certain peculiarities. Prior to the time of these workers, Veatch (1906 A), Owen (1860), Robertson (1867), Lockett (1870), Hilgard (1905), and Shepard (1905) had suggested various other theories of origin for the mounds.

Certain characteristics of mounds in northwestern Louisiana, and particularly in DeSoto and Red River Parishes, furnish additional evidence concerning the genesis of the mounds. These are:

1. The mounds are known to occur on Tertiary, on Pleistocene, and on Recent deposits alike. The number of mounds observed on Recent sediments is few.
2. Except in occasional instances the mounds have been observed to be most abundant on sandy or silty sediments.
3. The largest and most closely spaced mounds occur on terrace deposits.
4. In their observed occurrence on Tertiary deposits, the mounds

Figure 6. Pimple mounds on Prairie terrace surface in sec. 14, T. 14 N., R. 14 W., DeSoto Parish.

apparently tend to follow, at least with respect to abundance, the outcrop of the strata. In DeSoto Parish areas of abundant mounds circle the outcrop area of the Naborton formation. They occur in the outcrop area of the Naborton formation but are rare and poorly developed.

5. The mounds appear on flats, on hill tops, on hill sides, and in valley bottoms, but they are largest, most abundant, and best developed on sandy terrace flats and near the base of sandy hill sides where the slope is very slight.

6. The soil of the inter-mounds areas is heavier (higher percentage of clay and colloidal particles) than the soil of the mounds. (Personal communication with technicians of United States Soil Conservation Service of Upper West Red River District, Louisiana). It possesses poor internal drainage, a poorly developed profile, and exhibits a highly leached A horizon.

7. The soil of the mounds is friable, constant in character to a depth approximately equal to the height of the mound, and possesses good internal drainage. It consists normally of red or gray (usually grayish-yellow approaching straw color) fine to very fine sandy loam.

8. "Immature" mounds* are usually larger then mature mounds. They occur as partially connected hillocks up to 250-300 feet

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* "<u>Immature" mounds</u> consist of elongate or slightly rounded hillocks with a longer dimension as great as 300 feet and a height as great as 10 feet. In contrast, mature mounds are generally round, average less than 75 feet across and less than 5 feet in height.

in length, from approximately 100-300 feet across, and, in appearance, are still in the process of being eroded. The mature mounds are largely less than seventy-five feet across, and average from forty to fifty feet in diameter. The contrast between mature and "immature" mounds is observable in areas southeast of Gloster, DeSoto Parish (sections 20, 21, and 22, Township 14 North, Range 14 West) and due south of Kickapoo, DeSoto Parish (sections 1, 2, 11, and 12, Township 13 North, Range 15 West, and sections 6 and 7, Township 13 North, Range 14 West).

9. Mounds have been observed arranged in rows between small drains two and two-tenths miles due north of Frierson along the Kansas City Southern Railroad in section 22, Township 15 North, Range 13 West, DeSoto Parish. At least one tributary drain follows the west edge of a row of immaturely developed mounds and appears to be completing the process of isolating them. About two miles due south of Robson in Red River Parish, aerial photographs show what appear to be immature pimples on the back slope of the Red River natural levees. Here, the mounds, which vary from elongate ridges to essentially circular areas, occur in linear rows on the divides between small backslope drains. Additional examples of mounds now being formed by selective erosion of some type are to be seen in the following areas:

  1. Two miles due west of Frierson in section 32, Township 15 North, Range 13 West.

  2. Three and one-half miles east-northeast of Stonewall in section 11, Township 15 North, Range 14 West.

3. Two and one-half miles west of Keithville in Caddo Parish on the south side of the Keithville-Spring Ridge road.

4. Two and one-half miles north of Gloster on both sides of the Texas and Pacific Railroad.

5. Southeast of Gloster in sections 20, 21, and 22, Township 14 North, Range 14 West, and in sections 1 and 2, Township 13 North, Range 14 West.

6. East-northeast of Gloster in sections 13, 14, and 15, Township 14 North, Range 14 West (see fig.).

7. North of Holly on east side of Louisiana Highway 145 in sections 28 and 33, Township 14 North, Range 14 West.

On the basis of field observations, the writer is inclined to adhere to the erosion theory for most of the mounds in DeSoto and Red River Parishes. Protection of local areas by clump vegetation has been a contributing factor in many cases. The examples cited serve to exemplify the development from "immature" mounds near hill tops to more or less well developed "mature" mounds downslope. The majority of mounds occurring in the hills areas may be attributed to this mode of origin. Likewise, at least some of the mounds of the terrace provinces may also be included in this category. On the other hand, the majority of the floodplain and terrace mounds may be the result of still another genesis.

STRATIGRAPHY

Introduction

The surface deposits of DeSoto and Red River Parishes are confined to the upper Midway group (Paleocene), Sabine group (lower Eocene), and Quaternary alluvial deposits that unconformably overlie the older Tertiary deposits. Borings for oil and gas in these parishes have pierced sediments of upper and lower Cretaceous age and wells in adjacent parishes have penetrated Jurassic deposits. The stratigraphic and structural relationships of the surface formations are illustrated on figures 13 and 14. Figures 7, 8, 9, 10, and 11 show subsurface relationships of the Cretaceous and Jurassic sediments in this general region. Plate the geologic column, is also a stratigraphic chart summarizing the more important data pertaining to each formation.

The Jurassic sediments penetrated by borings in this general area consist of interbedded, dark shales, limestones, and sands with some red beds (Shreveport Geological Society, 1939, and Imlay, 1940). The lower Cretaceous (Comanche) sediments consist of dark shales, limestones, sands, anhydrite, and red and green, variegated shales. The upper Cretaceous (Gulf) deposits consist of limestones, shales, and chalks with some sand. Lignitic shales and clays with variable amounts of lime characterize the lower Midway deposits. The upper Midway and Sabine sediments consist of repetitious sequences of sand, lignitic silts, and calcareous silts and clays. Quaternary deposits consist of gravels, sands, silts, and clays.

The sedimentary strata of DeSoto and Red River Parishes represent three major lithologic stages: a lower marginal deltaic stage, a

Figure 15. Calcareous siltstone lentils surrounded by buff and gray, calcareous, lignitic silts and clays of the Naborton formation. Type locality of Naborton formation in SE¼, sec. 3, T. 12 N., R. 12 W., DeSoto Parish.

middle marine stage, and an upper fluviatile and deltaic stage. The lower lithologic stage, which consists predominantly of brackish and marine deltaic deposits with intercalated continental (?) strata, is assigned to the Upper Jurassic and to the Lower Comanche (Trinity and Coahuila time stages) on the basis of fossils (Shreveport Geological Society, 1939, and Imlay, 1940). The middle lithologic stage, which consists of limes, chalks, shales, and sands of marine origin, has faunas ranging from Fredericksburg to Lower Midway age. The upper lithologic stage, lower Midway and Sabine in age, consists of fluviatile, and brackish, and marine deltaic sediments.

The contrast between stages of deposition and stages of time indicated on the stratigraphic chart of this area (Plate V) emphasizes the acknowledged, but sometimes forgotten principle that faunas and lithologic boundaries often do not coincide. Schenck (1935) writes concerning a similar situation elsewhere:

> "No accurate correlations will be possible until time and rock units are separated in the investigator's mind and words, and the founding of locally named stages is a rational way to establish a satisfactory classification of the Tertiary rocks of the Pacific slope of North America." (p. 534).

Fisk (1938) in discussing the sedimentary complexities of the Vicksburg and Jackson groups of central Louisiana states:

> "The complexity of the sedimentary history of the Vicksburg and Jackson,....., makes separation into formations, mappable units, a futile task. The great irregularity and lack of continuity of either marine or non-marine phases in this area make correlation with so-called type-sections exceedingly difficult....For instance, the term group will be applied to the Vicksburg although the term does not satisfactorily designate the interrelated phases of sedimentation integrated by non-marine materials.
>
> It would seem far more logical to establish local units of deposition which would include a whole sequence of sedimentation." (p. 78).

Figure 16. Calcareous nodules on outcrop of Naborton formation in SW$\frac{1}{4}$, sec. 4, T. 12 N., R. 12 W., DeSoto Parish.

Similarly, it would seem logical that local stages of deposition "which include a whole sequence of sedimentation" are far more applicable to the DeSoto-Red River Parish area than the tangle of lithologic and paleontologic units now in usuage. A dual classification, consisting of lithologic and paleontologic (time) units would remedy the situation. Time and rock units would be separated and could be utilized individually or in combination. Time divisions, indicated by faunas, would not necessarily coincide with the boundary lines of the lithologic stages. Stages of deposition would be divisible into sub-stages, or facies, on the basis of lithology. Similarly, the time units would be divisible, with detailed study, into smaller time units limited by the vertical and geographical range of individual species.

Fisk (1940) pointed out the existence of "patterns of deposition" in the subsurface Tertiary sediments of central Louisiana. Combined surface and subsurface studies verify the existence of additional "patterns of deposition" in DeSoto and Red River Parishes and adjacent areas.

Beginning with the base of the Nacatoch sand, four general depositional patterns exist in central and northwestern Louisiana up to the top of the Miocene (see fig. 11). Within these great repetitions, smaller depositional repetitions are known to exist on the surface and in the subsurface.

Each of the large, general alternations begins with a basal sand, sandy marl, or marl. Lying above this stratum in order are marls, fossiliferous clays, lignitic clays, and, at the top, sparsely fossiliferous sands and lignitic silts and clays. The accompanying chart (Fig. 11) presents a synopsis of the cycles. The writer in no way means to assert or imply that a strict cyclic series of deposits exists here nor does he attempt to fit into this general pattern all sedimentary units of the

Figure 17. Thin-bedded, buff and gray, slightly calcareous, lignitic silts and clays exposed along local road in SW$\frac{1}{4}$, sec. 4, T. 12 N., R. 12 W., DeSoto Parish. Type locality of Naborton formation.

Gulf Coastal Plain area. However, certain repetitous sedimentary patterns do exist and knowledge of their existence should prove of value in unraveling the history of other masses of deltaic sediments.

The geologic history of each pattern begins with encroachment of the sea as a result of cessation of deltaic deposition. Basal beach sands and marls are first deposited and are overlain by fossiliferous clays with continued encroachment of the sea. The cycle reaches completion with recurrent deltaic sedimentation and seaward building of the land begins. Preceding this land advance are masses of lignitic shales deposited at the margins of the great deltaic masses. These lignitic shales have been termed "pro-deltaic sediments" by Fisk (unpublished; personal communication). Continued deltaic sedimentation results in the deposition of thick masses of sands and lignitic shales with incorporated fluviatile (channel and levee) sediments.

Tilting of the land coincident with downwarping of the continental margin in the Gulf Coast geosyncline has exposed the upper Midway and Sabine sediments in DeSoto and Red River Parishes. These sediments mark the youngest of the depositional patterns and consist of four formations, each of which has one or more repetitous sedimentary sequences beginning with a basal sand, overlain by a lignitic shale, in turn overlain by calcareous silts and clays.

The Naborton formation (lowest upper Midway) is not entirely exposed but can be divided at the surface into two members or facies of deposition.

Successively younger formations, the Logansport, Hall Summit, and Marthaville, each consist of a basal sand member, a middle lignitic shale member, and an upper calcareous silt and clay member.

Figure 18. Calcareous siltstone lentil surrounded by lignitic and limonitic sediments exposed at type locality of Naborton formation in SW¼, sec. 4, T. 12 N., R. 12 W., DeSoto Parish.

Isopach maps of the Midway and Sabine sedimentary masses (Fig. 12) indicate that the Midway and Sabine deposits exposed in DeSoto and Red River Parishes are located between two great Midway-Sabine deltas. Interpretation of the geological history as recorded by the sediments here must be based on a knowledge of the existence, location, and shifts in these major centers of deltaic sedimentation. The presence of marine tongues within the fluviatile and deltaic deposits of the upper Midway-Sabine sequence provides the means of correlation with marine sediments of Alabama, Mississippi, and Texas.

In contrast to the inter-deltaic position of northwest Louisiana during Midway-Sabine deposition, central and southern Mississippi seems to have been the center of deltaic accumulation. Eastward in Alabama, on the flanks of this great deltaic mass, pro-marginal deltaic and marine deposits were accumulating. Lateral shifting of the great rivers supplying sediments to the deltaic masses accounts for interfingering of the marginal deltaic and marine sediments of Alabama with the dominantly fluviatile and continental deltaic deposits of the Mississippi area. Still farther eastward in Alabama and Georgia the Paleocene-Lower Eocene section consists of limestones of marine origin. Conditions of deposition in the northwest Louisiana-northeast Texas area during Paleocene and Lower Eocene times closely approximated the conditions existing slightly west of the present Alabama-Mississippi state line. Westward in Texas, marine conditions prevailed at places, deltaic and fluviatile conditions at others.

Individual deltaic lithologic units are highly variable in thickness and type of material and generally can be mapped for short distances only. Individual strata extend over small vertical and horizontal areas; they rapidly change in facies and are replaced by other lithologic types.

Figure 19. Buff to gray, interbedded, lignitic clays, silts, and sands of the Naborton formation exposed in sec. 15, T. 12 N., R. 11 W., DeSoto Parish, along Louisiana Highway 9.

Surface work in the DeSoto-Red River Parish area, however, indicated certain lithologic sequences to be generally consistent in thickness over relatively wide areas. Within these sequences, however, thickness changes of facies are the rule rather than the exception. It is with this knowledge that the writer has tried to solve the geological history of this region through a study of the intricate sedimentary sequences within the great Sabine-Midway deltaic mass.

Subsurface Stratigraphy

Jurassic Deposits

Wells in DeSoto and Red River Parishes have not penetrated sediments of Jurassic age. However, wells within a few miles of the parish boundaries have almost 1300 feet of deposits of Jurassic age (see fig. 7).

On the stratigraphic chart (Plate V) the Morehouse, Eagle Mills, Smackover, Buckner, and Cotton Valley formations are assigned to the Jurassic system. These names were applied by Imlay (1940) and by the Shreveport Geological Society (1939, and personal communication) as a result of subsurface studies in the north Louisiana-south Arkansas area. Their Jurassic age has been determined by Imlay (1940) and Hazzard (1939 A).

Figure 20. Thin-bedded, gray to brown, lignitic silts, clays, and sands of the Naborton formation exposed in sec. 15, T. 12 N., R. 11 W., DeSoto Parish, along Louisiana Highway 9.

Cretaceous Deposits

Introduction

Wells in DeSoto and Red River Parishes penetrate the entire Gulf Cretaceous sequence and most of the Comanche Cretaceous sequence.

The terminology of the subsurface Cretaceous deposits of northwestern Louisiana has long been complicated. Recent work by Grage and Warren (1939), the Shreveport Geological Society (1939), and Imlay (1940), on the Cretaceous stratigraphy of northwestern Louisiana and southwestern Arkansas has resulted in the introduction of several new formational names for the lower Cretaceous (Comanche) sediments and in the partial revision of upper Cretaceous (Gulf) nomenclature.

The formational names employed on the stratigraphic chart (Plate V), on the cross sections (Figs. 7, 8, 9, and 10), and in the stratigraphic discussions are those adopted by Imlay (1940) and the Shreveport Geological Society (1939) for northwestern Louisiana and southwestern Arkansas. The new formational names applied to the lower Cretaceous (Comanche) sediments have been proposed on a basis of subsurface data though their equivalents are known to crop out in Arkansas and Oklahoma. They have been traced southward from the outcrop area into northwestern Louisiana (Hazzard and Lloyd, 1939, p. 89).

The name Hosston supplants "Travis Peak", formerly used in this area for beds older than the Travis Peak of Texas (Imlay, 1940, p. 28). The Trinity group, which previously consisted of the Paluxy and "Glen Rose", is subdivided into six formations. The "Lower Glen Rose" of this area is now divided into the Sligo, Pine Island, and Rodessa formations. The name Ferry Lake has been proposed for the former "Glen Rose" or "Massive Anhydrite". Mooringsport has been proposed for beds heretofore called "Upper Glen Rose". No subdivisions or nomenclatural revisions of the Fredericksburg are applied in this area.

The upper Cretaceous (Gulf) formational names employed here are those of the Shreveport Geological Society (Guidebook, 14th Annual Field Trip, 1939). The formations are exposed in Arkansas and northeast Texas and have been traced from the outcrop into the subsurface (Hazzard and Lloyd, 1939).

The formational limits of the subsurface strata in DeSoto and Red River Parishes that are shown on the cross sections (Figs. 7, 8, 9, and 10) are based on combined electrical log and lithologic studies. The formations represent lithologic or rock units employed in subsurface mapping, and, surface formations, they interfinger, lens-out, and are at places gradational. These lithologic units do not everywhere carry the same fauna.

The most important deep wells in the DeSoto-Red River Parish area are listed at the end of the section on Cretaceous stratigraphy. Electrical logs of these wells have formed the basis of the lithologic distinctions herein presented. Partial faunas are listed for each fossiliferous lithologic unit.

Coahuila Group

Hosston Formation

Only two wells (see figs. 7, 9, 10) in DeSoto and Red River Parishes have definitely penetrated the Hosston formation. Wells within a few miles of the parish boundaries in Caddo and Bienville Parishes have penetrated over two thousand feet of beds assigned to the Hosston formation. These sediments consist of interbedded red shales and sandy shales, sands, and fossiliferous limy sands, limestones and shales. Several wells drilled into the Hosston formation in area of DeSoto and Red River Parishes have encountered quite fossiliferous sediments.

The basal Cretaceous, Hosston formation, was defined for the first time by Imlay (1940) to replace the old name "Travis Peak", which, as applied in Louisiana, referred to beds older than the Travis Peak of Texas. The evidence for this and for placing the Hosston formation in the Coahuila Group is summarized by Imlay (1940, pp. 29-30). He says:

> "The age of the Hosston formation is known within limits by its position a couple hundred feet below the Pine Island formation whose basal beds contain several species of the ammonite Dufrenoya. This genus is indicative of the lower Trinity of the Gulf region and Mexico, and of the upper Aptian of Europe. Therefore, the Hosston formation, which underlies the Sligo formation transitionally, must be of Lower Cretaceous age, but older than the Trinity. It belongs in the Coahuila group which includes Lower Cretaceous formations older than the Dufrenoya texana zone. Whether it represents all or only part of the Coahuila group is not known.
>
> The Hosston formation is correlated in part with the lithologically similar Las Vigas formation of northern Mexico and southwestern Texas. Other correlations should not be made until the age of the Cotton Valley formation has been determined definitely. By comparisons with the Mexican section, it may be expected that the Hosston formation grades southward into marls and limestones in central Louisiana."

Imlay (1941) reports the presence of species of Astarte, Lucina, Panope, Exogyra, and Cardium from the Hosston. He says:

> "None of these indicates an age older than the lower Cretaceous. Panope is questionably represented in the Jurassic period but is fairly common thereafter. One species of Cardium was obtained from the upper part of the Hosston formation at a depth of 6,260 to 6,280 feet in the Prairie River Syndicate Hutchinson No. 1 well, located in section 15, Township 15 North, Range 12 West, Caddo Parish, Louisiana. This Cardium is unusual because it bears radial ribs on both its anterior and posterior margins like the

> the unique *Cardium germani* Pictet and Campiche from the Valanginian of Switzerland."

Samples available from the Prairie River Syndicate, Hutchinson well in section 15, Township 15 North, Range 12 West, Caddo Parish, have yielded a few casts of macrofossils and some microfossils. In cores of this well between 6,250 and 6,300 feet species of *Cardium*, *Exogyra*, *Leda*, and *Lucina* (?) were observed. Among the microfossils, species of *Haplophragmoides*, *Ammobaculites*, *Quinqueloculina*, *Guttulina*, *Globulina* (?), *Trochammina*, *Textularia*, *Cythere*, *Cytherella*, *Cytheridea*, *Loxoconcha* (?), *Monoceratina*, and *Macrocypris* (?) were also observed.

Trinity Group

Sligo Formation

The name Sligo was proposed by the Shreveport Geological Society for gray and brown shales containing local lenses of sandstone and limestone. These beds were formerly included in the lowermost Lower Glen Rose formation. Imlay (1940, p. 30) who used the term says:

> "It is understood that the Nomenclature Committee of the Shreveport Geological Society will describe the type section and show graphically the boundaries of the formation in a forthcoming paper."

The type locality is the Sligo field of Bossier Parish.

As used herein, the Sligo formation includes the sediments from the uppermost red beds of the Hosston formation to the top of the "three-finger limestone" lentil or its equivalents. In the DeSoto-Red River Parish area, the formation consists of dark shales and limestones. It is similar in character to the overlying Pine Island formation but is more limy in character. The formation varies from approximately five hundred to seven hundred and fifty feet in thickness in this area. Its stratigraphic relationships are indicated on the cross sections (Figs. 7, 9, 10).

The Sligo formation is correlated with the lowest Trinity beds as it underlies the Pine Island formation whose lower beds contain lower Trinity fossils. The Shreveport Geological society correlates the formation with the lower Travis Peak of Texas.

The fauna of the Sligo formation has not been studied separately but has been considered in connection with the other so-called "Lower Glen Rose" faunas of the Rodessa and Pine Island formations (see p. 70). The scarcity of available samples has prevented more detailed studies of this portion of the Comanche Series.

Pine Island Formation

As now defined, the Pine Island formation contains the dark shales with interbedded limestones and sandstone, formerly assigned to the Lower Glen Rose, lying above the "three-finger limestone" lentil and below the James limestone member of the Rodessa formation.

The formation was first defined by Crider (1938) for beds here referred to as the Hosston formation. Imlay (1940) reports, however, that the name, Pine Island, was originally proposed by the Shreveport Geological Society for the dark marine shales and limestones above the uppermost red beds of the Hosston formation and below the James limestone lentil. The Shreveport Geological Society has subsequently decided to restrict the name, Pine Island, to the dark shales with some interbedded limestones and sandstone lying above the "three-finger limestone" lentil and below the James limestone member (Imlay, 1940, p. 32). As thus defined the Pine Island formation contains some red beds and more shale than the underlying Sligo formation. The type locality is the Pine Island field of northwestern Louisiana.

In DeSoto and Red River Parishes, the Pine Island formation consists of dark shales and interbedded limestones with some sandy shale. In this area it varies in thickness from slightly less than two hundred feet to more than three hundred feet; the average thickness is two hundred feet.

The Pine Island formation has been assigned to the lower part of the Trinity because of the presence of species of the ammonite genera Dufrenoya and Prochelaniceras (Imlay, 1940, p. 33). The Shreveport Geological Society correlates the lower portion of the Pine Island formation with the Travis Peak of Texas, the upper portion with the Glen Rose of Texas.

The scarcity of samples in this portion of the Comanche series has necessitated the consideration of the Pine Island fauna with those of the Sligo and Rodessa formations. These faunas are discussed on p. 70.

Rodessa Formation

The Rodessa formation was named by the Shreveport Geological Society (1939) and contains all strata between the underlying Pine Island formation and the overlying Ferry Lake Anhydrite (see figs. 7, 9, 10). The type locality of the formation is in the Rodessa field on the Texas-Louisiana line. The type section and boundaries of the formation are to be described by the Shreveport Geological Society in a forthcoming paper. It corresponds to the upper part of the section long known as the Lower Glen Rose.

In DeSoto and Red River Parishes, the Rodessa formation consists of dark colored, porous limestones, limy shales, anhydrite, mudstones, and sandstones. The limestones are commonly oolitic; fossils are common. A few red beds are present in the section.

The formation varies in thickness from as much as four hundred and fifty feet in eastern Red River Parish to less than three hundred and fifty feet in western DeSoto Parish. From north to south it maintains a rather uniform thickness of approximately three hundred and fifty feet. On the basis of known information, it is lower Trinity in age.

The porous limestones of the Rodessa formation afford good possibilities for future production of oil and gas. These limestones are the main producing zone in the Logansport field, and, should the porosity be present farther east, the Sutherlin, Spider, Grand Cane, Mansfield, and DeSoto-Red River-Bull Bayou structural highs are potential gas producing areas.

The faunas of the Sligo, Pine Island, and Rodessa formations, formerly classed as lower Glen Rose are considered here as a unit. The writer has made few determinations of fossils from these beds but has relied largely upon published information for the following data.

Hazzard (1939) reports the following forms present in the "Lower Glen Rose" (Sligo, Pine Island, and Rodessa formations), (identifications by Scott, Imlay, and Adkins):

Cephalopoda

Douvilleiceras (?) or Procheloneceras sp.
Dufrenoya texana (Burckhardt)
Pseudosaynella (?) sp.
Aconeceras (?) or Pseudosaynella (?) sp.
Parahaplites (?) sp.
Pseudosaynella cf. bicurvatum
"Rhytidhoplites robertsi Scott"
Hypacanthoplites sp.
Procheloniceras

Pelecypoda

Protocardia sp.
Anomia (?) sp.
Protocardia sp. (small)
Astarte sp.
Monopleura (?) sp.
Exogyra quitmanensis

Gastropoda

Anchura (?) sp.
Vermetus (?) sp.

The writer has observed the following forms present in the Sligo-Pine Island-Rodessa sequence:

Foraminifera

Anomalina (?) sp.
Bolivina sp.
Cristellaria sp.
Globigerina sp.
Gümbelina sp.
Gyroidina sp.
Masselina sp.
Patellina sp.
Quinqueloculina sp.
Textularia sp.

Ostracoda

Bairdia (?) sp.
Brachycythere sp.
Bythocypris rotundus Vanderpool
Cythereis spp.
Cytherella sp.
Cytheridea sp.
Cytheropteron sp.
Eocytheropteron cf. E. tumidum Alexander
Eucythere sp.
Loxoconcha spp.
Pontocypris cf. P. perforata Vanderpool

Pelecypoda

Ostrea sp.

Gastropoda

Aporrhais (?) sp.

Ferry Lake Anhydrite

The Ferry Lake anhydrite (formerly known as the "Massive Anhydrite") consists, in DeSoto and Red River Parishes, of two hundred to two hundred and fifty feet of gray to white, crystalline anhydrite with small amounts of interbedded gray to black shale, limestone, and dolomite. The formation lies conformable above the Rodessa formation and conformably below the Mooringsport formation. The type section and the boundaries of the formation are now being described by the Shreveport Geological Society.

The formation is present everywhere in DeSoto and Red River Parishes that wells have been drilled deep enough. It maintains a rather constant thickness throughout this entire area. The base of the massive anhydrite section serves as an excellent contouring horizon.

The Ferry Lake formation is thought to be of middle Trinity age. It is correlated with the middle portion of the Glen Rose limestone of Texas. No fossils have been observed in the sediments of this formation. The subsurface relationships of the Ferry Lake anhydrite are shown on the accompanying cross sections (Figs. 7, 9, and 10).

Mooringsport Formation

The Mooringsport formation consists in DeSoto and Red River Parishes of approximately seven hundred and fifty feet of interbedded, gray to black, limy shales and gray limestones. Brown and red shales, sandy shales and fine-grained sandstones are locally present. In the lower portion of the formation two anhydrite stringers are generally present. Lenses of fossiliferous limestone and shale also occur. The formation conformably overlies the Ferry Lake formation and is transitional with the overlying Paluxy formation. It thins slightly in the western part of DeSoto Parish. Its subsurface relationships are indicated on the cross sections (Figs. 7, 9, and 10).

The Mooringsport formation is correlated with the upper portion of the Glen Rose limestone of Texas. In the few cores available for study the only important fossil observed to be common in the Mooringsport sediments was Orbitolina texana (Roemer). In addition species of Textularia, Haplophragmoides, Ammobaculites, Cristellaria, Globigerina, Quinqueloculina, Globorotalia, Valvulineria (?), Clavulinoides, Cytheridea, Massalina, Dorothia, Monoceratina, Orthonotocythere, Bairdia, Brachycythere (?), Liopistha (?), and Leda were observed in well samples from this formation. In samples from a depth of 5,010-5,025 feet in the W. J. Hunter, Stoer No. 1 well, section 10, Township 15 North, Range 15 West, Caddo Parish, Bairdia glenrosensis Vanderpool, Bairdia dorsoventrus Vanderpool, Bythocypris rotundus Vanderpool, and Cytheropteron trinitiensis (Vanderpool) were observed. Samples from the Arkansas Fuel Oil Co., Franklin Realty Co. No. 1, (depth 4,810-4,860 feet) yielded Bairdia cf. B. glenrosensis Vanderpool, Cytheropteron trinitiensis (Vanderpool), Haplostiche cf. H. texana (Conrad), chara seeds, and a species of Leda.

Paluxy Formation

The Paluxy formation of DeSoto and Red River Parishes consists of more or less unfossiliferous, red, green, gray, and brown shales and sands and interbedded gray limestones, shales and thin sandstones. The formation averages approximately twelve hundred feet in thickness and is present in all wells drilled in these parishes. It is transitional into the underlying Mooringsport formation. Where the Fredericksburg is present it is conformable on the Paluxy. In the area of the DeSoto-Red River-Bull Bayou field, the Fredericksburg is absent and the Paluxy is overlain unconformably by the Eagle Ford formation of the Upper Cretaceous (see figs. 7, 8, 9, and 10). The Paluxy-Fredericksburg contact in the subsurface follows an approximate southeast-northwest line through the vicinity of Kingston, Holly, the western edge of the DeSoto-Red River-Bull Bayou field, and the southeastern corner of DeSoto Parish.

The Paluxy formation contains the main producing zone in the DeSoto-Red River-Bull Bayou and Pleasant Hill fields. The production here is from sands and sandy shales within one hundred and fifty feet of the top of the Lower Cretaceous (Paluxy). Sporadic production has also been secured from the Paluxy at several other places in these parishes.

The Paluxy is upper Trinity in age and is correlated with the upper portion of the Glen Rose limestone of Texas. A few sparsely fossiliferous samples from sediments of Paluxy age yielded the following forms:

<u>Foraminifera</u>

Ammobaculites subgoodlandensis Vanderpool
Haplophragmoides sp.
Ramulina sp.
Reophax subgoodlandensis Vanderpool
Textularia sp.

<u>Ostracoda</u>

Cytherelloidea subgoodlandensis Vanderpool
Cytheridea aff. C. amygdaloides (Cornuel)
Cytheropteron cf. C. bicornutum Alexander
Cytheropteron trinitiensis (Vanderpool)
Eocytheropteron cf. E. howelli Alexander
Eocytheropteron sp.

Fredericksburg-Wshita Groups

(Undifferentiated)

The interval between the "red beds" of the Paluxy formation and the Eagle Ford formation consists of an undifferentiated sequence of limestones, limy sands, and sandy shales here referred to the Fredericksburg and Washita (see figs. 7, 8, 9, and 10). By a comparison with known stratigraphic sequences, the greater portion of this section is believed to consist of sediments of Fredericksburg age. The Washita is known to be present in Texas northwest of DeSoto Parish. Its position in the subsurface section of DeSoto and Red River Parishes is not known to the writer.

The Fredericksburg sediments exist under all of DeSoto Parish west of a line passing approximately through Kingston, the Holly field, the western edge of the DeSoto-Red River-Bull Bayou field, and the southeast corner of DeSoto Parish. In the absence of paleontological data, the extent of the Fredericksburg in the area east of the DeSoto-Red River-Bull Bayou field is not known.

The Fredericksburg sediments are believed completely absent over the DeSoto-Red River-Bull Bayou field. Elsewhere in DeSoto Parish they attain a maximum thickness of slightly over two hundred and fifty feet.

Fossiliferous samples of Fredericksburg sediments from wells in southern and western DeSoto Parish contained the following forms:

Foraminifera

Ammobaculites goodlandensis Cushman and Alexander
Ammobaculites cf. A. subcretacea Cushman and Alexander
Ammodiscus sp.
Eponides sp.
Frankeina goodlandensis Cushman and Alexander
Globigerina sp.
Haplophragmoides sp.

cf. Haplostiche texana (Conrad)
Lagenammina (?) sp.
Lenticulina sp.
Lituola sp.
Nodosinella sp.
Orbitolina texana (Roemer)
Patellina sp.
Polymorphina sp.
Spiroplectammina goodlandana Lalicker
Textularia rioensis Carsey
Vaginulina (?) sp.
Verneulina schizea Cushman and Alexander

Ostracoda

Brachycythere sp.
Cythereis carpenteri Alexander
Cythereis fredericksburgensis Alexander
Cythereis mahonae Alexander
Cytherella comanchensis Alexander
Cytherella fredericksburgensis Alexander
Cytherella scotti Alexander
Cytherelloidea sp.
Cytheridea cf. C. amygdaloides (Cornuel)
Cytheridea washitaensis Alexander
Eocytheropteron tumidum Alexander
Paracypris sp.

Pelecypoda

Gryphea cf. G. navia Hall
Pecten sp.
Protocardia cf. P. texana (Conrad)

Lower Cretaceous-Upper Cretaceous Contact

In DeSoto and Red River Parishes, the Upper Cretaceous lies unconformably upon the Fredericksburg or Paluxy sediments of the Lower Cretaceous (Figs. 7, 8, 9, and 10). Over most of this area the missing interval represents most or perhaps all of Washita time. Elsewhere the interval represents both Fredericksburg and Washita times. The irregularity of the Fredericksburg-Paluxy surfaces on which Eagle Ford sediments rest, coupled with the unmistakable variations in thickness of the Fredericksburg and Eagle Ford sediments further substantiates this unconformable relationship. Similarly, the marked faunal break between the Eagle Ford and the Fredericksburg or Washita evidences a considerable time lapse in this portion of the geologic column. Finally, the absence of Woodbine or equivalent sediments from this area also indicates a lapse of time here.

Gulf Series

Woodbine Group

No representatives of the Woodbine Group are known to exist in DeSoto and Red River Parishes.

Eagle Ford Group

Sediments of Eagle Ford age in DeSoto and Red River Parishes consist in general of fossiliferous, usually calcareous, brown, gray, or black shales, sandy shales, and sands. In eastern Red River Parish gray and brown, calcareous and non-calcareous, generally coarse-grained, tuffaceous sediments, U. Tusc. or Lewisville (Center Point volcanics, Hazzard, 1939), are present in the lower third of the Eagle Ford. Chloritic, pyritic, and conglomeratic facies are present in these tuffaceous sediments. Westward in Red River and DeSoto Parishes, the volcanic facies are unknown.

The Eagle Ford varies from approximately twenty-five to one hundred and fifty feet in thickness. It attains its greatest thickness in eastern Red River Parish and in southern and western DeSoto Parish. The sandy facies of the Eagle Ford are potential oil and gas producing zones. The production in the Holly Oil and Gas field is believed to be from channel sands of Eagle Ford age resting unconformably on the Fredericksburg.

The Eagle Ford rests unconformably upon the Fredericksburg or Paluxy sediments (see figs. 7, 8, 9, and 10). It is overlain conformably by the Ector Tongue of the Austin chalk.

Fossiliferous samples of the Eagle Ford have produced the forms listed here:

Foraminifera

Anomalina eaglefordensis Moreman
Frondicularia cordai Reuss
Globotruncana arca (Cushman)
Gümbelina globulosa (Ehrenberg)
Hastigerinella moremani Cushman
Quinqueloculina moremani Cushman
Spiroplectammina terquemi (Berthelin)
Vaginulina simondsi Carsey
Vaginulina webbervillensis Carsey

Ostracoda

Cythereis eaglefordensis Alexander
Cythereis spp.
Cytherella munsteri (Roemer)
Bairdia cf. B. alexandrina Blake
Cytheropteron eximium Alexander

Pelecypoda

Inoceramus prisms

Ammonoidea

Baculites sp.

Austin Group

Ector Chalk

Throughout all of DeSoto and Red River Parishes, so far as known, the basal portion of the Tokio formation consists of a calcareous facies correlated with the Ector Tongue of the Austin chalk. In this area, the Ector Tongue consists of white to gray, soft or hard chalk, chalky shale, and shale with some interbedded gray limestones and marl. The chalky portion of the Ector Tongue maintains a rather constant thickness of about one hundred and ten feet in Red River Parish and in the eastern two-thirds of DeSoto Parish. This thickness decreases slightly northward and increases somewhat southward.

The Ector conformably overlies the Eagle Ford formation and is transitional into the overlying Tokio shales and sandy shales. Its stratigraphic relationships are shown on the cross sections (Figs. 7, 8, 9, and 10).

Important microfossils observed in samples of the Ector chalk are:

Foraminifera

Anomalina taylorensis Carsey
Euovigerina cf. E. serrata (Chapman)
Flabellammina rugosa Alexander and Smith
Frondicularia austinana Cushman
Globigerina cf. G. cretacea d'Orbigny
Globigerinella sp.
Globotruncana canaliculata (Reuss)
Gümbelina sp.
Neobulimina irregularis Cushman and Parker
Hastigerinella alexanderi Cushman
Redtogumbelina texana Cushman
Textularia sp.

Ostracoda

Brachycythere sphenoides (Reuss)
Cythereis parallela (Reuss)
Cythereis semiplicata (Reuss)

Cythereis sp.
Krithe (?) sp.

Brownstown and Tokio Formations

The stratigraphic interval between the base of the Ector chalk tongue and the base of the Ozan formation consists of sands and shales with varying amounts of lime known as the Brownstown and Tokio formations. In general these sediments are indivisible without detailed paleontologic data. For convenience the writer has grouped the Brownstown and Tokio sediments as a unit. The Ector Tongue of the Austin chalk (basal portion of the Tokio formation in this area) is a distinct lithologic and paleontologic unit.

The Tokio formation conformably overlies the Eagle Ford formation, the Brownstown conformably underlies the Ozan formation. The top of the Brownstown is drawn at the base of the Buckrange sand member of the Ozan formation. The base of the Tokio formation is drawn at the base of the Ector Tongue member.

The Brownstown-Tokio interval represents a period of deposition of dominantly shaly sediments. In the lower portion these sediments consist dominantly of chalk with interbedded limes, shales, and marls. The middle portion is composed of gray to brown shales and sandy shales with small amounts of calcareous material, while the upper portion consists of interbedded, gray to brown shales, sandy shales, sands, limy sand, and locally soft marls. In this area a persistent sand, sandy shale, or limy sand about two hundred feet below the base of the Buckrange sand is believed to be the equivalent of the Blossom sand of Texas.

The Brownstown-Tokio sequence maintains an average thickness throughout DeSoto and Red River Parishes of seven hundred and fifty feet (see figs. 7, 8, 9, and 10).

Fossiliferous facies of the Brownstown-Tokio sequence have yielded the following microfissils:

Foraminifera

Anomalina taylorensis Carsey
Bouvigerina plummerae Cushman
Flabellammina clava Alexander and Smith
Frondicularia archiaciana d'Orbigny
Gaudryina (Siphogaudryina) cf. G. carinata Franke
Globigerina cretacea d'Orbigny
Globotruncana arca (Cushman)
Globotruncana fornicata Plummer
Hastigerinella alexanderi Cushman
Hemicristellaria ensis (Reuss)
Pleurostomella watersi Cushman
Rectogümbelina texana Cushman

Ostracoda

Brachycythere sp.
Brachycythere sphenoides (Reuss)
Cythereis austinensis Alexander
Cythereis bicornis Alexander
Cythereis hazardi Israelsky
Cythereis ornatissima (Reuss)
Cytherella bullata Alexander
Cytheropteron furcalatum Alexander
? Cytheropteron tokiana Israelsky
Monoceratina pedata (Marsson)

Mollusca

Cardium sp.
Inoceramus prisms
Natica sp.

Taylor Group

Ozan Formation

The Ozan formation of DeSoto and Red River Parishes consists of an upper shaly and chalky member, and a lower sandy member. The upper member is composed of white to dark gray, usually fossiliferous, shale, chalky shale, and chalk. The lower portion, termed the Buckrange sand member, is gray of brown, sandy shale, sand, or limy sand. The Buckrange is best developed in the vicinity of the DeSoto-Red River-Bull Bayou field in east central DeSoto Parish and west central Red River Parish (see figs. 7, 8, 9, and 10). In eastern Red River Parish and in western DeSoto Parish the porosity of the Buckrange is decreased so that in these areas there is less chance of its being a producing zone than elsewhere.

The formation approximates one hundred and forty feet in thickness throughout this area. It conformably overlies the Brownstown formation and in turn is conformably overlain by the Annona formation. It is considered lower Taylor in age. The base of the Ozan chalk is the best subsurface mapping horizon in this area. Both the regional and oil field subsurface structural maps of DeSoto and Red River Parishes are contoured on this contact. The microfossils listed here have been found in samples from the chalk portion of the Ozan formation:

Foraminifera

Anomaline complanata Reuss
Anomalina taylorensis Carsey
Arenobulimina presli (Reuss)
Bolivinoides decorata (Jones)
Buliminella carseyae Plummer
Cibicides excolata (Cushman)
Clavulina sp.
Frankeina taylorensis Cushman and Waters
Frondicularia gracilis Franke
Gaudryina (Siphogaudryina) carinata Franke
Globotruncana arca (Cushman)
Gyroidina depressa (Alth)
Gyroidina (Eponides ?) micheliniana (d'Orbigny)
Heterostomella faveolata (Marsson)
Kyphopyxa christneri (Carsey)
Lituola taylorensis Cushman
Loxostoma clavatum (Cushman)
Loxostoma tegulatum (Reuss)
Neobulimina spinosa Cushman and Parker
Planulina taylorensis (Carsey)
Pseudoclavulina amorpha (Cushman)

Pseudogaudryinella capitosa (Cushman)
Pseudouvigerina plummerae Cushman
Tritaxia sp.

Ostracoda

Bairdia rotunda Alexander
Cythereis ozanana Israelsky
Cythereis plummeri (?) Israelsky
Cythereis thomasi Israelsky
Cytheropteron furcalatum Alexander
Eucytherura chelodon (Marsson)
Orthonotacythere hannai (Israelsky)

A few fossiliferous samples of the Buckrange (sand) member of the Ozan contained these forms:

Foraminifera

Anomalina taylorensis Carsey
Bolivinoides decorata (Jones)
Buliminella carseyi Plummer
Frankeina taylorensis Cushman and Waters
Gaudryina carinata Franke
Gümbelina striata Ehrenberg
Haplophragmoides excavata Cushman and Waters
Loxostoma clavatum (Cushman)
Losostoma plaitum (Carsey)
Neobulimina spinosa Parker and Jones
Pseudoclavulina amorpha (Cushman)
Vaginulina cf. V. regina Plummer

Ostracoda

Alatacythere sp.
Brachcythere sphenoides (Reuss)
Brachcythere taylorensis (Alexander)
Cythereis plummeri (?) Israelsky
Cytherella complanata (Reuss)
Cytherella parallela (Reuss)
Eucytherura chelodon (Marsson)
Krithe cushmani Alexander

Annona Formation

In the DeSoto-Red River Parish area the Annona formation consists of blue or dark gray to white, fossiliferous chalk and chalky shale. It averages one hundred and twenty-five feet in thickness throughout this area. Both its upper and lower limits conform with adjacent beds. The stratigraphic relationships of the Annona are shown on the cross sections (Figs. 7, 8, 9, 10, 13, and 14).

Numerous oil and gas shows have been encountered throughout the parishes in the Annona and some commercial production has been obtained from this formation. Consequently, it must be considered a potential producing zone throughout DeSoto and Red River Parishes.

The Annona formation is considered to be middle Taylor in age.

The fauna is best developed in the chalk facies and is dwarfed in numbers or is almost entirely absent in the shaly facies. To some extent the typical Annona fauna is present in the highly chalky facies of the underlying Ozan formation.

Among the more important microfossils observed in Annona samples are:

Foraminifera

Anomalina grosserugosa (Gümbel)
Anomalina pertusa (Marsson)
Anomalina taylorensis Carsey
Astacolus taylorensis (Plummer)
Bolivinoides decorata (Jones)
Buliminella carseyi Plummer
Cibicides excolata (Cushman)
Clavulinoides disjuncta (Cushman)
Clavulinoides trilatera (Cushman)
Dorothia pupoides (d'Orbigny)
Ellipsonodosaria alexanderi Cushman
Eouvigerina americana Cushman
Flabellammina compressa (Beissel)
Flabellina projecta (Carsey)

Flabellina rugosa d'Orbigny
Flabellina suturalis Cushman
Frondicularia archiaciana d'Orbigny
Globotruncana arca (Cushman)
Globotruncana canaliculata (Reuss)
Goesella chapmani Cushman
Gümbelina excolata Cushman
Gyroidina depressa (Alth)
Gyroidina (Eponides ?) micheliniana (d'Orbigny)
Heterostomella foveolata (Marsson)
Kyphopyxa christneri (Carsey)
Lituola taylorensis Cushman and Waters
Loxostoma tegulatum (Reuss)
Marssonella oxycona (Reuss)
Pseudoclavulina amorpha (Cushman)
Planulina taylorensis (Carsey)
Tritaxia sp.

Ostracoda

Bairdia rotunda Alexander
Bairdia subdeltoidea (Münster)
Cythereis ozanana Israelsky
Cythereis semiplicata (Reuss)
Cythereis thomasi Israelsky
Cytheridea perforata (F. A. Roemer)
Cytheropteron blakei Alexander
Krithe cushmani Alexander

Mollusca

Inoceramus prisms

Marlbrook Formation

The Marlbrook formation (uppermost Taylor) of this area includes the sequence of marls and shales lying conformably above the Annona formation and below the Saratoga formation (see figs. 7, 8, 9, 10, 13, and 14). The Marlbrook consists of gray to brown, glauconitic, shell marls and grayish, limy or chalky, fossiliferous shales. It averages about one hundred and fifty feet in thickness throughout this area. The chalky facies of the Marlbrook thickens southward at the expense of the shale facies so that in the southern portions of DeSoto and Red River Parishes and in northern Sabine and Natchitoches Parishes the Marlbrook is lithologically similar to the Saratoga and Annona. The Marlbrook thins slightly eastward across DeSoto and Red River Parishes.

The most important fossils observed in well samples from these parishes are:

<u>Foraminifera</u>

Anomalina grosserugosa (Gümbel)
Anomalina pertusa (Marsson)
Anomalina ripleyensis (W. Berry)
Anomalina taylorensis Carsey
Astacolus taylorensis Plummer
Bolivinoides decorata (Jones)
Buliminella carseyi Plummer
Buliminella fabilis Cushman and Parker
Cibicides excolata (Cushman)
Clavulinoides insignis (Plummer)
Eponides micheliniana (d'Orbigny)
Flabellammina saratogensis Cushman
Flabellina interpunctata von der Marck
Flabellina cf. F. projecta (Carsey)
Frankeina taylorensis Cushman and Waters
Frondicularia goldfussi Reuss
Gaudryina rudita Sandidge
Gaudryina (Siphogaudryina) stephensoni Cushman
Globotruncana arca (Cushman)
Globotruncana fornicata Plummer
Gümbelina globifera (Reuss)
Gyroidina micheliniana (d'Orbigny
Lagena sp.
Lituola taylorensis Cushman and Waters
Spiroplectammina semicomplanata (Carsey)
Trochammina diagonis (Carsey)
Tritaxia sp.
Ventilabrella cf. V. carseyae Plummer

<u>Ostracoda</u>

Alatacythere (?) cornuta (F. A. Roemer) var. gulfensis Alexander
Alatacythere sp.
Brachycythere sphenoides (Reuss)
Cythereis thomasi Israelsky
Cythereis (?) sp.
Cytheridea perforata (F. A. Roemer)
Cytheridea plummeri Alexander
Cytherella parallela (Reuss)
Krithe cf. K. cushmani Alexander

Mollusca

Inoceramus prisms

Navarro Group

Saratoga Formation

The Saratoga formation, of lower Navarro age, averages about fifty feet in thickness in the DeSoto-Red River Parish area. It consists largely of gray to white, hard to soft, glauconitic, fossiliferous chalk with small amounts of chalky shale and shale. The chalk facies thins slightly eastward at the expense of shale and clay. Southward the chalk section thickens rapidly so that in southern DeSoto Parish the entire Saratoga sequence is chalk and is difficult to distinquish from the underlying Marlbrook. The Saratoga is transitional into the lower part of the overlying Nacatoch formation. In areas where the lower portion of the Nacatoch is chalky or shaly the Saratoga and Nacatoch are normally distinquished on a paleontologic basis only, though close analysis of electrical logs often produces evidence of a lithologic break from shales or chalky shales (Nacatoch) to chalk below (Saratoga).

The relationships of the Saratoga are indicated on the accompanying cross sections (Figs. 7, 8, 9, 10, 13, and 14).

Important fossils observed in the Saratoga in well samples from this area are:

Foraminifera

Anomalina pertusa (Marsson)
Anomalina pseudopapillosa Carsey
Anomalina rubiginosa Cushman
Arenobulimina presli (Reuss)

Buliminella carseyi Plummer
Cibicides constricta (c. Hagenow)
Cibicides excolata (Cushman)
Cibicides involuta (Reuss)
Clavulinoides insignis (Plummer)
Clavulinoides trilatera (Cushman)
Dentalina granti Plummer
Discorbis correcta Carsey
Dorothia bulleta (Carsey)
Flabellammina saratogaensis Cushman
Flabellina rugosa d'Orbigny
Flabellina suturalis Cushman
Frondicularia dinida Bagg
Frondicularia frankei Cushman
Gaudryina rudita Sandidge
Globotruncana arac (Cushman)
Globotruncana fornicata Plummer
Gümbelina excolata Cushman
Gyroidina depressa (Alth)
Hemicristellaria ensis (Reuss)
Heterostomella faveolata (Marsson)
Lenticulina navarroensis (Plummer)
Lituola taylorensis Cushman and Waters
Loxostoma plaitum (Carsey)
Marginulina taylorana Cushman
Marssonella oxycona (Reuss)
Planulina cf. P. taylorensis (Carsey)
Pseudopolymorphina cuyleri Plummer
Pseudouvigerina cretacea Cushman
Pullenia cretacea Cushman
Robulus navarroensis (Plummer)
Spiroplectammina anceps (Reuss)
Vaginulina webbervillensis Carsey
Ventilabrella carseyae Plummer

Ostracoda

Alatacythere sp.
Brachycythere ledaforma (Israelsky)
Cytheropteron navarroense Alexander
Loxeconcha fletcheri Israelsky

Nacatoch Formation

The Nacatoch formation (middle Navarro in age) in this area consists of approximately one hundred and fifty feet of generally hard, fine- to coarse-grained, glauconitic, fossiliferous, gray to brown sand with interbedded gray shales and gray to white chalk. The sand section thins in the southern, western, and eastern portions of the area and is replaced by shale and chalk. The entire formation thins to about one-fourth its average thickness in southern DeSoto and northern Sabine Parishes. Its subsurface relationships are shown on the accompanying cross sections (Figs. 7, 8, 9, 10, 13, and 14).

The formation is transitional into the underlying Saratoga formation. Where the lower portion of the Nacatoch formation is chalky, lithologic differentiation of the formations is difficult and their separation must be made on a paleontologic basis. Normally, however, their differentiation on electrical logs is rather easy. The Arkadelphia-Nacatoch contact is somewhat irregular in the area of the DeSoto-Red River-Bull Bayou field and may evidence a break in sedimentation between the formational units. In most other areas the contact is transitional from the sandy shale of the Nacatoch formation into the dark clays of the Arkadelphia, or is a sharp lithologic break from sand below to clays above.

Important fossils observed in well samples from this formation are:

Foraminifera

Anomalina grosserugosa (Gümbel)
Anomalina pseudopapillosa Carsey
Buliminella carseyae Plummer var. plana Cushman and Parker
Bullopora chapmani (Plummer)
Clavulinoides insignis (Plummer)
Cornuspira involvens (Reuss)
Discorbis correcta Carsey
Dorothia bulleta (Carsey)
Dorothia pupoides (d'Orbigny)
Flabellina reticulata Reuss
Globigerina cretacea d'Orbigny
Globigerina cf. G. pseudobulloides Plummer
Globigerina rugosa Plummer
Globotruncana arca (Cushman)
Globotruncana fornicata Plummer
Globulina communis (d'Orbigny)
Gümbelina globulosa (Ehrenberg)
Gümbelina striata (Ehrenberg)
Gyroidina depressa (Alth)
Haplophragmoides rugosa Cushman and Waters

Hemicristellaria ensis (Reuss)
Hemicristellaria silicula Plummer
Lenticulina navarroensis (Plummer)
Lituola taylorensis Cushman and Waters
Loxostoma plaitum (Carsey)
Loxostoma tegulatum (Reuss)
Planulina complanata (Reuss)
Polymorphina cushmani Cushman
Ramulina globifera H. B. Brady
Reophax texana Cushman and Waters
Rotalia sp.
Siphogenerinoides plummeri (Cushman)
Tritaxia sp.
Vaginulina cf. V. simondsi Carsey
Ventilabrella carseyae Plummer

Ostracoda

Alatacythere sp.
Brachycythere ledaforma (Israelsky)
Brachycythere ovata (Berry)
Bairdia magna Alexander
Cythereis hazardi (Israelsky)
Cytherella tuberculifera Alexander

Arkadelphia Formation

The Arkadelphia formation includes those beds carrying an upper Navarro fauna that conformably overlie the Nacatoch formation and conformably underlie the Kincaid (Midway) formation in this area. The sediments consist of light to dark gray, chalky or calcareous, fossiliferous, glauconitic clays and silty shales. Lithologically, the Arkadelphia formation is similar to the overlying Midway sediments rather than to the underlying Nacatoch sediments. The Arkadelphia-Kincaid contact (Cretaceous-Tertiary) is conformable and generally must be picked by paleontology. However, the general vicinity of the contact can usually be picked on electrical logs.

The Arkadelphia formation thins slightly to the west and south in DeSoto and Red River Parishes. The subsurface relationships of the formation are shown on the accompanying cross sections (Figs. 7, 8, 9, 10, 13, and 14).

Important microfossils observed in well samples of the Arkadelphia in this area are:

Foraminifera

Anomalina grosserugosa (Gumbel)
Anomalina cretacea (Reuss)
Anomalina navarroensis Plummer
Bolivina incrassata Reuss
Bulimina pupoides d'Orbigny
Buliminella cf. B. carseyi Plummer
Bullopora chapmani (Plummer)
Clavulinoides insignis (Plummer)
Dentalina reussi Neugeborn
Discorbis correcta Carsey
Dorothia bulleta (Carsey)
Dorothia pupoides (d'Orbigny)
Flabellina interpunctata von der Marck
Flabellina reticulata Reuss
Frondicularia reticulata (Reuss)
Frondicularia arkadelphiana Cushman
Gaudryina navarroensis Cushman
Gaudryina rudita Sandidge
Globigerina aequilateralis H. B. Brady
Globigerina cretacea d'Orbigny
Globigerina rosetta Carsey
Globotruncana arca (Cushman)
Globotruncana cf. G. fornicata Plummer
Globulina communis (d'Orbigny)
Globulina gibba (d'Orbigny)
Gümbelina globifera (Reuss)
Gümbelina striata (Pseudotextularia ?) Ehrenberg
Hemicristellaria ensis (Reuss)
Hemicristellaria silicula Plummer
Lenticulina cultrata (Montfort)
Lenticulina navarroensis (Plummer)
Lituola taylorensis Cushman and Waters
Loxostoma plaitum (Carsey)
Nodosaria vertebralis (Batsch)
Planulina complanata (Reuss)
Polymorphina cushmani Plummer
Pseudotextularia a, b, c, and d of Plummer
Ramulina globulifera H. B. Brady
Siphogenerinoides plummeri (Cushman)
Spiroplectammina sp.
Textularia navarroana Cushman
Uvigerina (?) seligi Cushman
Vaginulina gracilis Plummer var. cretacea Plummer
Vaginulina cf. webbervillensis Carsey

Ostracoda

Alatacythere sp.

Important Wells

Important deep wells of the DeSoto-Red River Parish area employed in the subsurface lithologic and paleontologic studies are:

W. L. McClanahan, Frost Johnson Lumber Co. No. 1, section 22, Township 9 North, Range 13 West, Sabine Parish, total depth 5,710 feet.

J. F. McMannon, et al., Cook Land Co. No. 1, section 16, Township 10 North, Range 11 West, DeSoto Parish, total depth 3,514 feet.

J. E. Watts, Patterson Heirs No. 1, section 35, Township 10 North, Range 11 West, Sabine Parish, total depth 3,425 feet.

Arkansas Fuel Oil Co., Franklin Realty Co. No. 1, section 20, Township 11 North, Range 9 West, Red River Parish, total depth 7,120 feet.

Paul H. Miller, Jal Drilling Co. No. 2, section 5, Township 11 North, Range 11 West, DeSoto Parish, total depth 4,205 feet.

Superior Oil Co., M. D. Joyner No. 1, section 22, Township 11 North, Range 12 West, DeSoto Parish, total depth 5,001 feet.

J. L. Ryan, Tr., Jackson No. 1, section 1, Township 11 North, Range 14 West, DeSoto Parish, total depth 5,509 feet.

Southern Production Co., Frost-Billingsley Unit Well No. 1, section 1, Township 11 North, Range 16 West, DeSoto Parish, total depth 4,781 feet.

Southern Production Co., Alston-Frost Unit Well No. 1, section 11, Township 11 North, Range 16 West, DeSoto Parish, total depth 4,931 feet.

Southern Production Co., Gannon-Frost Unit Well No. 1, section 12, Township 11 North, Range 16 West, DeSoto Parish, total depth 4,977 feet.

Dixie Oil Co., Jenkins No. 1, section 9, Township 12 North, Range 11 West, DeSoto Parish, total depth 6,149 feet.

Magnolia Petroleum Co., J. C. Pugh No. 59, section 12, Township 12 North, Range 11 West, Red River Parish, total depth 6,471 feet.

District Oil Co., Frank Grocery Co. No. 1, section 26, Township 12 North, Range 11 West, DeSoto Parish, total depth 3,005 feet.

Petroleum Heat and Power Co., John Matthews No. 1, section 29, Township 12 North, Range 11 West, DeSoto Parish, total depth 4,007 feet.

Flesh and Hootkins, Mrs. J. S. Farmer No. 1, section 14, Township 12 North, Range 13 West, DeSoto Parish, total depth, 3,038 feet.

Snow Drilling Co., Stell No. 1, section 5, Township 12 North, Range 16 West, DeSoto Parish, total depth, 6,002 feet.

The Hunter Co., Inc., F. F. Parker No. 1, section 26, Township 12 North, Range 16 West, DeSoto Parish, total depth, 4,863 feet.

W. J. Hunter, Long Bell Lumber Co. No. 1, section 19, Township 13 North, Range 9 West, Red River Parish, total depth, 3,733 feet.

W. J. Hunter, Long Bell Lumber Co. No. 2, section 20, Township 13 North, Range 9 West, Red River Parish, total depth, 3,995 feet.

A. G. Bernardi, Clifton No. 1, section 33, Township 13 North, Range 12 West, DeSoto Parish, total depth, 5,692 feet.

E. T. Oakes, et al., Johnston No. 1, section 30, Township 13 North, Range 15 West, DeSoto Parish, total depth, 5,466 feet.

Gulf Refining Co., Good Pine No. 1, section 25, Township 14 North, Range 8 West, Bienville Parish, total depth, 10,770 feet.

Twin-Cities Drilling Co., Sundby-Garland No. 1, section 7, Township 14 North, Range 14 West, DeSoto Parish, total depth, 5,073 feet.

Prairie River Syndicate, Hutchinson No. 1, section 15, Township 15 North, Range 12 West, Caddo Parish, total depth, 9,141 feet.

W. J. Hunter, N. B. Stoer No. 1, section 3, Township 15 North, Range 15 West, DeSoto Parish, total depth, 6,562 feet.

J. M. Conner, G. C. Williams No. 1, section 14, Township 15 North, Range 15 West, Caddo Parish, total depth, 5,102 feet.

Surface Stratigraphy

Tertiary Sediments

Introduction

The Tertiary sediments of DeSoto and Red River Parishes are here assigned to the Midway (Paleocene) and Sabine (lower Eocene) groups. (See geologic maps, plates I, II, and IV). Formerly, all surface exposures of Tertiary age in this area were assigned to the Sabine or "Wilcox" group.

Recent studies by members of the Louisiana Geological Survey indicate that the lower 800-900 feet of sediments cropping out in DeSoto and Red River Parishes are upper Midway in age. Detailed field mapping in this area resulted in the subdivision of these upper Midway surface deposits into three formations (Naborton, Hall Summit, and Logansport) and six members which are here described for the first time. The Kincaid formation and "Midway black shales" do not crop out on the surface in this area but they are included in this section on surface stratigraphy to preserve the continuity of the Midway stratigraphy.

The upper two hundred feet of sediments cropping out in these parishes are assigned to the Sabine group. They belong to one formation, the Marthaville, with three lithologic facies.

A brief description on each new formation and member is given in the following discussion. Type lithologic sections and geologic cross sections (Figs. 13, 14) are presented to illustrate the stratigraphic and structural relationships of these formations. Partial faunas and floras are listed for each formation.

The outcrop areas of the formations are shown on the geologic maps (Plates I, II, and IV). Good exposures of each formation are indicated within its outcrop area on the geologic maps (Plates I, and II) by an X. The location of the best fossil localities are shown on the regional map (Plate IV).

Paleocene Series

Midway Group

Historical Summary

Smith and Johnson (1887) first applied the term Midway when they used it to designate the oldest Eocene strata in Alabama. Harris (1894 A, B) employed the term in his discussions of the geology of southern Arkansas, of Maryland, and of Virginia, and suggested that it be separated from the Lignitic. In 1896, Harris defined the Midway group as a paleontologic and stratigraphic unit of the first rank, overlain by Nanafalia beds of the Sabine (Lignitic) and underlain by the Cretaceous. The Naheola, Sucarnoochee, and Clayton formations of Alabama were included within these boundaries.

The first known usage of the term "Midway" in Louisiana was made by Harris and Veatch (1899, p. 63) at which time they referred sediments exposed at Rocky Springs church in Sabine Parish and at Drake's Salt Dome in Bienville Parish to the Midway stage. Eleven years later Harris (1910, p. 122) stated that "...Midway beds must occur at the surface over a considerable area to the north" (of Marthaville). In the same report he presented a geological map showing Midway strata on the surface in the northwestern area of Natchitoches Parish between Bayou Pierre and Marthaville. The Hall Summit and Logansport formations (Midway) of the present bulletin include the entire area mapped by Harris as Midway in 1910. Howe (1925) showed the Rocky Springs church locality to lie within the outcrop area of the Sabine Group. Spooner (1926) did not map Midway strata on his map of the area. Moody (1931) mapped all the strata below the Claiborne as Wilcox.

The period after Harris witnessed many references to the Midway in subsurface correlation. These referred in part to the upper Midway of the present report, in part to the lower calcareous Midway shales which were generally referred to as the Arkadelphia. Hull (1925) indicated the presence of Midway on the Bisteneau and Vacherie Domes of Webster Parish and the Prothro Dome of Bienville Parish. Howe (1925) showed the necessity of applying the term Midway to certain subsurface beds formerly included in the upper part of the Arkadelphia formation. Moody (1931) presented additional information on the extent and sedimentation of the Midway in the Sabine Uplift area. Alexander (1935) showed the presence of both Kincaid and Wills Point faunas in subsurface beds referred to the Midway in southwest Arkansas and northwest Louisiana.

LeBlanc and Barry (1941) and Murray (1941) pointed out the presence of Midway fossils on the surface in the sediments stratigraphically below the Ostrea thirsae zone and above the Midway black shales in northwestern Louisiana. The fossils are closely related to those of the Wills Point formation of Texas and the Naheola formation of Alabama.

Age

Harris (1894 A, B, 1896) defined and set up the Midway (from Midway Landing on the west side of the Alabama River in Wilcox County, Alabama) as a distinctive unit of the Tertiary. This separation was based on the disappearance of the coiled cephalopods (except Hercoglossa), the disappearance of Gryphaea and Trigonia, and the appearance and development (for the first time in the Gulf Coast) of Venericardia and Calyptrophorus. Virtually all workers since this time have followed Harris in assigning the Midway to the Eocene. Scott (1926, 1934), however, on the basis of faunal studies, believes the Midway is equivalent to the uppermost Cretaceous (Danian) of Europe. Simpson (1932) reported the presence of a Paleocene mammal from a well in Caddo Parish and thereby first proved the presence of Paleocene sediments in the subsurface in Louisiana. Gardner (1941), who has recently analyzed the Midway molluscan fauna of the western Gulf Province and indicated additional relationships and differences in the fauna, considered the Midway Paleocene in age. Stephenson and Reeside (1938), Toulmin (1940), and Stephenson and Monroe (1940) preceded Gardner in assigning the Midway to the Paleocene series.

The Midway group in Louisiana is here redefined to include all sediments stratigraphically below the Marthaville formation of the Sabine group and above the Arkadelphia formation of the Gulf Series. In this sense it includes the Mansfield sub-group of Howe and Garrett (1934), the lower part of the Wilcox group of Moody (1930), and the Midway black shale unit of numerous other authors.

The contact of the Midway group with the underlying Arkadelphia (uppermost Cretaceous) is conformable in DeSoto and Red River Parishes on the basis of information available at the present ime. The contact with the overlying basal sands of the Sabine group (Marthaville formation) is also conformable wherever exposed in Red River Parish.

Midway Sub-divisions

The Midway deposits of DeSoto and Red River Parishes are divided on the basis of lithologic and faunal facies into five units, three of which are new. These are:

5. Hall Summit formation
4. Logansport formation
3. Naborton formation
2. "Midway black shales"
1. Kincaid formation

Kincaid Formation

Gardner (1933) proposed the name Kincaid for the basal limy sediments of the Midway group of Texas. Alexander (1935) applied the name Kincaid to subsurface sediments in northwestern Louisiana that carry a Kincaid foraminiferal assemblage.

In the DeSoto-Red River Parish area the Kincaid formation is not exposed at the surface, but the writer has been able to study it in cores obtained from wells in DeSoto and Red River Parishes and adjacent areas. Data obtained from studies of cores and electrical logs in this area indicate that the Kincaid formation varies in thickness from fifteen to fifty feet (see figs. 7, 8, 9, 10, 13, and 14). On the basis of available information, the Kincaid is thicker in southern DeSoto and northern Sabine Parishes, in western DeSoto and in eastern Shelby and Panola Counties, Texas, than in central and northern DeSoto Parish.

The lithology of the Kincaid formation in this area is rather constant. It consists of gray, calcareous, usually fossiliferous shale or clay with occasional chalk lenses and calcareous concretions. Occasional glauconite grains were observed. No macrofauna has been determined from this formation. In cores taken from the Flesh and Hootkins, Mrs. J. S. Farmer No. 1 well, section 14, Township 12 North, Range 13 West, DeSoto Parish, the following diagnostic foraminifera were obtained:

Core, 1,064-1,076 feet:

Hard, light to dark gray, calcareous shale:

Anomalina midwayensis var. trochoides (Plummer)
Cristellaria midwayensis (Plummer)
Cristellaria orbicularis (d'Orbigny)
Cristellaria turbinata (Plummer)
Eponides exigua (H. B. Brady) var. limbata (Plummer)
Vaginulina gracilis (Plummer)
Vaginulina legumen (Linnaeus) var. elegans d'Orbigny

Numerous other non-diagnostic foraminifera and ostracoda were present in these samples.

"Midway Black Shales"

Alexander in 1935 applied the name "Wills Point" to lignitic and limy shales in the subsurface of northwestern Louisiana and Arkansas which overlie sediments containing a Kincaid microfauna. He indicated these sediments to be equivalent to the Wills Point formation of Texas (see Plummer, 1932). These shales are overlain by approximately 900 feet of surface beds which also carry a Wills Point fauna.

Since the entire sequence of beds between the top of the Kincaid formation and the base of the Hall Summit formation (uppermost Midway in this area) carries a fauna correlated with the Wills Point formation of

Texas, that formational name should not be applied to a portion of these strata. For this reason the writer will refer to the lignitic, limy shales overlying the Kincaid and underlying the Naborton formation as "Midway black shales".

The "Midway black shales" of this report average from 500 to 600 feet in thickness and consist of lignitic and limy shales and clays with occasional calcareous concretions. They do not crop out on the surface in DeSoto and Red River Parishes.

Lithologically, the contact between this sequence and the underlying Kincaid formation is transitional and generally can be picked only on a faunal basis. The contact with the overlying Naborton formation is transitional from silty clays into sands and silts. The contact is generally selected at the base of the last dominantly sandy strata encountered in drilling (see figs. 13, 14). On electrical logs (see figs. 7, 8, 9, 10) the contact normally is marked by a decrease in the self-potential and resistivity curves.

Alexander (1935) was the first to point out that the faunas of the Wills Point and Kincaid formations in the subsurface of Louisiana and south Arkansas are transitional. Samples within a few feet of the contact generally contain a mixture of Kincaid and Wills Point species. <u>Vaginulina gracilis</u> Plummer and <u>Vaginulina robusta</u> Plummer occur together in this transitional faunal zone.

The following species of foraminifera have been observed in samples of the "Midway black shales" from several wells in DeSoto and Red River Parishes:

Ammobaculites expansus Plummer
Ammobaculites midwayensis Plummer
Ammodiscus incertus (d'Orbigny)
Anomalina (Cibicides ?) alleni (Plummer)
Anomalina cultur (Parker and Jones)

Anomalina midwayensis (Plummer)
Anomalina midwayensis (Plummer) var. trochoidea Plummer
Anomalina welleri (Plummer)
Clavulinoides midwayensis Cushman
Cristellaria longiforma Plummer
Cristellaria midwayensis Plummer
Cristellaria pseudocostata Plummer
Cristellaria trigonata Plummer
Eponides exigua H. B. Brady var. limbata Plummer
Frondicularia delicatissima Plummer
Frondicularia goldfussi Reuss
Globigerina triloculinoides Plummer
Globigerina sp.
Gyroidina soldanii (d'Orbigny) var. subangulata Plummer
Marginulina costata (Batsch)
Marginulina tumida Reuss
Nodosaria granti Plummer
Nodosaria cf. N. oligotoma Reuss
Polymorphina cushmani Plummer
Spiroplectammina expansa (Plummer)
Textularia plummerae Lalicker
Vaginulina legumen (Linneaus) var. elegans d'Orbigny
Vaginulina robusta Plummer
Vaginulinopsis echinata Thalmann

Naborton Formation

Definition

The Naborton formation contains the oldest beds known to be exposed in DeSoto and Red River Parishes. The formation is proposed to include all strata between the "Midway black shales" and the overlying basal sand (Dolet Hills) member of the Logansport formation. It is named for the town of Naborton in section 10, Township 12 North, Range 12 West, in east central DeSoto Parish.

The Naborton formation below the Chemard Lake lignite lentil consists of rapidly changing facies of generally calcareous, buff to gray, fine to medium sands, clays, and lignitic silts (see figs. 15-22). The maximum exposed thickness of the formation is almost 200 feet.

In the subsurface it varies in thickness from 150 feet to slightly over 200 feet. The type locality comprises exposures along a local road leading from Louisiana Highway 9 to Bethlehem Church (between Naborton and Goss) in sections 3 and 4, Township 12 North, Range 12 West. The section exposed here is (see figs. 15, 16, 17, 18):

Paleocene Series

Midway Group

Naborton formation	Thickness
Top elevation, 235 feet (Paulin altimeter)	
13. Soil and wash overlying gray, calcareous silts and clays	5'
12. Black to brownish-black, lignitic clays	6"
11. Gray, blue-gray, and rusty-brown, laminated, clayey silts carrying some fossil leaves, calcareous	9'
10. Gray, laminated, very fine, sandy silts	5'
9. Thinly laminated, lime- and iron-cemented, fine-grained siltstone (appears to be lenticular)	6-12"
8. Gray and buff to rusty-brown, laminated, clayey silts. Iron is concentrated in more sandy laminations, making it hard and platy. Upper 6" highly stained with iron	7'
7. Rusty-brown and reddish, soft, fine-grained sandstone appearing more or less massive but with thin seams of gray to blue-gray clay and silt. Concentrations of iron form concretionary-like structures	12'
6. Gray, blue-gray, and buff, laminated, lignitic silts	7'
5. Brown, lignitic clay and lignite	1'
4. Blue-black to chocolate-brown shale with conchoidal fracture, some rusty iron stains	3'
3. Blue-gray to buff, calcareous, laminated, fine silts and clays	7'

Figure 21. Buff and gray, thin-bedded, slightly calcareous silts and clays of the Naborton formation exposed on north side of local road in SW$\frac{1}{4}$, sec. 11, T. 12 N., R. 12 W., DeSoto Parish, three-quarters of a mile east of Naborton.

2. Same as 3 but slightly more sandy, thin, platy, iron-cemented laminae present. Calcareous .... 5'

1. Same as 3 and 2 but more massively bedded ..... 5'

Total thickness 67'-67'6"

Dip of beds to the west.

Eastward on this same local road in sections 3 and 4, Township 12 North, Range 12 West, sandy, clayey, and calcareous facies of the Naborton formation are exposed.

The base of the formation is not exposed on the surface in DeSoto and Red River Parishes. The contact with the overlying Logansport formation is exposed along Louisiana Highway 9, in sections 9 and 10, Township 12 North, Range 12 West, one mile west of Naborton at the junction of the road south to Truevine Church.

Paleocene Series

Midway Group

Logansport formation

Dolet Hills member — Thickness

Top elevation, 340 feet (Paulin altimeter)

12. Soil and weathered sand .... 30'

11. Gray to brown, irregular, fine- to medium-grained, micaceous sand and silt with irregular ferruginous concentrations .... 15'

Naborton formation

10. Gray to black, massive to blocky, lignitic, silty clays (Chemard Lake lignite lentil) ...... 5'

9. Gray to buff, thin-bedded to massive, silty and clayey sand. Upper portion chocolate-brown in color and dominantly silt .... 15'

8. Gray to brown to buff, medium-bedded, salt and pepper, fine- to medium-grained, micaceous sand. Ferruginous laminae prominent and iron content high in upper portion .... 30'

Figure 22. Small fault in Naborton sediments exposed in SW$\frac{1}{4}$, sec. 5, T. 12 N., R. 12 W., DeSoto Parish, on north side of Louisiana Highway 9. Maximum displacement, 20 feet.

7. Gray to black, lignitic clay	3'
6. Dark gray lignitic clay with well preserved plant impressions	6"
5. Fine sand, upper 18" thin-bedded and clayey, lower portion almost massive	5'
4. Zone of coarser sand lenses with concretionary structure. Sand cemented with limonite and calcite, well indurated	5'
3. Fine, evenly bedded, gray to brown silty sand ..	6'
2. Covered	5'
1. Gray argillaceous silt (outcrops in creek)	2'
Total thickness	121'6"

Entire sequence up to top of first lignitic clay contains numerous small white calcareous concretions.

Good exposures of the contact are also visible in the north edge of the Dolet Hills in the SE¼ of Township 12 North, Range 12 West, the NE¼ of Township 11 North, Range 12 West, and the northern third of Township 11 North, Range 11 West. For the stratigraphic relationships of this contact see figures 7, 8, 9, 10, 13, and 14.

The Naborton formation crops out in a topographic basin over an area of approximately sixty square miles in DeSoto Parish and over an area of less than one square mile in Red River Parish. (See maps, plates I, II, and IV). The outcrop is relatively rugged but local "prairies" and flat lands developed on calcareous silts and clays break the general continuity of hills.

Lignite (the Chemard Lake lignite lentil) or lignitic clay marks the contact of the Naborton formation with the overlying basal sand member of the Logansport formation. The contact is drawn at the top of this lignitic zone. At places, where the lignitic material is

Figure 24. Lignitic and limonitic clays, silts, and sands exposed at type locality of Logansport formation beneath U. S. Highway 84 bridge across Sabine River at Logansport, DeSoto Parish. Dolet Hills and Cow Bayou members of Logansport formation.

absent, the Naborton silts and clays grade directly into the sands of the overlying Dolet Hills member.

Although the base of the Naborton formation is at no known place brought to the surface by uplift, the basal beds of the formation have been studied by means of electrical logs, lithologic logs and samples from shallow borings. Borings within the outcrop area of the Naborton formation encounter calcareous silts, clays, and sands before penetrating the "Midway black shales". The base of the last sandy sequence above the "Midway black shales" marks the base of the Naborton formation. In other parts of the parishes, the formation is also limited at the top by the Dolet Hills (sand) member and at the base by the "Midway black shales".

The Naborton formation is the basal sequence of the lignitic sand and shale portion of the lowest great lithologic alternation in northwestern Louisiana (see fig. 11). Within the formation itself, several small scale alternations of sand, lignitic shale, and calcareous silts and clays (top to bottom) have been observed.

The relationships of the Naborton formation to adjacent beds is shown on the cross sections (Figs. 13, 14).

The Chemard Lake Lignite Lentil

The Chemard Lake lignite lentil of the Naborton formation consists of lignite and lignitic clays with a maximum known thickness of ten feet. It is limited at the top by the basal sands of the Logansport formation, the Dolet Hills member. The lignite and lignitic clays interfinger on the outcrop and mutually replace each other or are both replaced by the sediments in the upper part of the Naborton formation. The type

Figure 25. Loose, massive sand of the Dolet Hills member of the Logansport formation exposed at the type locality in sec. 1, T. 11 N., R. 12 W., DeSoto Parish, along local road between Naborton and Grove Hill church.

locality is exposed one mile northwest of Chemard Lake at Coal Bed Springs in the bluffs facing Dolet Brake and Dolet Bayou, in the NW$\frac{1}{4}$ of section 3, Township 11 North, Range 11 West, two and one-half miles southwest of Evelyn and two miles northwest of Rambin's store, DeSoto Parish. The stratigraphic section exposed at the type locality is:

Paleocene Series

Midway Group

	Thickness
Logansport formation	
Top elevation, 210 feet (Paulin altimeter)	
6. Fine- to medium-grained, massive sand	60'
Naborton formation	
Chemard Lake lignite lentil	
5. Thin, limonitic lamina	-$\frac{1}{4}$"
4. Lignite	1'
3. Gray, silty clay	3"
2. Lignite	5'6"
1. Dark gray, carbonaceous clay, transitional into lignite (Base covered)	13'
Total thickness	69'9$\frac{1}{4}$"

Basal elevation, 140 feet (Paulin altimeter)

Additional fine exposures occur in sections 5, 6, and 7, Township 11 North, Range 11 West. An excellent exposure of the member occurs in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, section 6, Township 11 North, Range 11 West, DeSoto Parish. The section cropping out there is:

Paleocene Series

Midway Group

Logansport formation	Thickness
7. Massive, gray to brown, medium-fine sand	30'
Naborton formation	
Chemard Lake lignite lentil	
6. Lignitic clay	3"
5. Lignite	8"
4. Buff to tan, bedded clay	3"
3. Lignite	6'6"
2. Gray to almost black underclay	2'
1. Gray to buff, slightly calcareous clays, (base covered)	2'
Total thickness	41'8"

Elevation, top of main lignite seam, 165 feet (Paulin altimeter)

The Chemard Lake lignite lentil has been traced approximately ten miles to the west of its outcrop area and four miles to the south in the subsurface. It has been traced on the surface around the entire southern portion of the outcrop area of the Nabortion formation from Chemard Lake to Rockdale (Township 12 North, Range 12 West).

Deposition of the Naborton Formation

The Naborton formation represents fluviatile and deltaic deposition. The absence of animal life, the abundance and well preserved nature of the flora, and the lenticularity of the sedimentary facies suggests that deposition occurred in a flood plain or marsh environment.

Figure 26. Thin-bedded, chocolate-brown, lignitic silts and clays exposed in $SW\frac{1}{4}$, sec. 9, T. 10 N., R. 14 W., on south side of Hunter-Converse gravel road, DeSoto Parish. Type locality of Cow Bayou member of Logansport formation.

Distinctive Characteristics

The Naborton formation is distinguished in the field by the following criteria:

1. Soils. The soils of the Naborton formation belong to the group of heavy, slowly permeable, poorly developed upland soils. They are in general reddish to tan in color, alkaline, compact, and sticky. They are much less sandy than the overlying Chemard Lake and Cow Bayou members of the Logansport formation and are restricted in general to the outcrop area of the Naborton formation. Dominant soil types occurring in the outcrop area are: Cuthbert very fine sandy loam, Guin undifferentiated soils, Boswell very fine sandy loam, and Shubuta very fine sandy loam. Generally these soils are characterized by red, usually mottled, heavy clay B horizons.
2. Vegetation. The flora growing on the Naborton formation is characterized by an abundance of blue stem grass, legumes, and dwarfed or scrubby underbrush. Lespedeza "quail" or partridge pea, wild vetch of several types, false indigo, post-oaks, haws, elm, and yupons are present in great numbers. Pines are locally abundant on the more sandy soil facies.
3. Concretions. Small, irregularly shaped limonitic concretions are more abundant in the Naborton formation than in any other portion of the upper Midway sequence. Large limonitic and calcareous concretions are also quite common. Some of the larger calcareous concretions have a length of almost fifteen feet.
4. Fossils. The Naborton formation is distinguished so far as

Figure 27. Interbedded, chocolate-brown clay and gray silts of Cow Bayou member exposed in ravine in SW$\frac{1}{4}$, sec. 9, T. 12 N., R. 13 W., DeSoto Parish, back of High School in town of Mansfield.

far as known by a total absence of animal remains, and by an abundance of well preserved remains.

Paleontology and Age

Much of the flora of the Naborton formation has been described. W. Berry (1916) reported fifty-three species of plants from exposures near Naborton, on which basis he assigns the strata to the top of the middle Wilcox. Plants are usually best preserved in the calcareous and limonitic concretions, though excellent remains have been found in the lignitic silts of this formation. No animal remains of any kind have been found in sediments of the Naborton formation, but the sediments immediately above it and immediately below it carry a foraminiferal fauna similar to that present in the Wills Point formation of Texas.

Economic Resources

The lignites and soils of the Chemard Lake member are its only known economic resources. The lignites have been employed occasionally for fuel but there is little demand for them. In general, the soils are unproductive.

Logansport Formation

Definition

The Logansport formation is proposed to include all strata between the underlying Naborton formation and the overlying Hall Summit formation.

Figure 28. Gray, slightly lignitic and calcareous, argillaceous silts exposed in old brick pit in SW$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 9, T. 12 N., R. 13 W., in town of Mansfield, DeSoto Parish. Cow Bayou member of Logansport formation.

It is subdivided into the following members:

3. Lime Hill (calcareous silts and clays)
2. Cow Bayou (lignitic shales)
1. Dolet Hills (sand)

Logansport on the Sabine River in west central DeSoto Parish is designated as the type locality. In this region near the crest of the Logansport anticline, the dip is nearly horizontal and the following thirty-foot section (see fig. 24), near the middle of the formation, is exposed at low water for three miles upstream from the town:

Pleistocene Series	
Montgomery formation	Thickness
Top elevation, 205 feet (Paulin altimeter)	
7. Yellowish-brown to gray, fine-to medium-grained sand with some gravel	30'
Paleocene Series	
Midway Group	
Logansport formation	
Cow Bayou member	
6. Chocolate-brown to gray, thinly bedded, lignitic, jointed silts and clays with traces of plant impressions	6'
5. Hematitic, occasionally nodular, sandstone	3'
4. Chocolate-brown to black, thinly bedded, jointed, silty clays and silts with discoid, ferruginous concretions and occasional leaf fragments. Sulfur-yellow stains on surface	8'
Dolet Hills member	
3. Gray to brown, nodular, slightly lignitic sand with clay pellets	3'
2. Nodular, irregular, hematitic sandstone. Gradational into underlying bed	2'
1. Gray to brown, nodular, cross-bedded sand with occasional lignitic particles and clay pellets ..	4'
Total thickness	56'

Figure 29. Calcareous, leaf-bearing, siltstone lentils exposed in old brick pit in SW¼, SE¼, sec. 9, T. 12 N., R. 13 W, in town of Mansfield, DeSoto Parish. Cow Bayou member of Logansport formation.

It is unfortunate that the name Mansfield is preoccupied for over one hundred feet of typical Logansport sediments are exposed near this town (see figs. 25, 26, 27).

The contact of the Logansport formation with the overlying Hall Summit formation is transitional (see fig. 30) and is drawn at the top of the calcareous silts and clays of the Lime Hill member. The contact of the Logansport with the underlying Naborton formation is also transitional and is drawn at the base of the Dolet Hills member, the top of the Chemard Lake (lignite) lentil.

The Logansport formation crops out (see geologic maps, plates I, II, and IV) over all of DeSoto Parish except for the outcrop areas of the Naborton formation and the Quaternary deposits. It is exposed in northern Sabine and Natchitoches Parishes, in eastern Shelby and Panola Counties, Texas, in southern Caddo Parish, and in a belt in Red River Parish flanking the eastern edge of the Red River flood plain. The outcrop area forms an irregularly circular pattern around the DeSoto-Red River-Bull Bayou field. Local structures such as Benson and Logansport bring the formation upward and interrupt its normal outcrop belt.

The basal sand member forms a ring of rugged, highly dissected hills rimming the Naborton formation on three sides; the middle lignitic shale member forms, in general, rolling topography with rather poor exposures; and, the upper calcareous unit possesses rolling to rugged topography. The deposits in Red River Parish occur largely as poor exposures beneath the Pleistocene formations.

The formation, from subsurface and surface studies, has a maximum thickness slightly over four hundred feet in southeastern DeSoto, northwestern Natchitoches, and northeastern Sabine Parishes (see figs. 13, 14).

Figure 30. Mottled, brick-red and gray, interbedded, argillaceous, silts and sands exposed along Louisiana Highway 404 in N½, sec. 3, T. 9 N., R. 10 W., Natchitoches Parish. Transition zone between Logansport and Hall Summit formations.

Members of Logansport Formation

Dolet Hills Member

The Dolet Hills member consists of fine-to medium-grained, massive sands which attain a maximum thickness of one hundred and twenty-five feet and an average thickness varying between forty and seventy-five feet. Silt and clay lenses and thin lignite seams are present in the sands. The member interfingers with the overlying Cow Bayou member and is transitional from the underlying Naborton formation.

The Dolet Hills member takes its name from the Dolet Hills in central-southeast DeSoto Parish where it attains its greatest thickness and best development. The type locality is designated to consist of exposures in the NW¼ of section 6, Township 11 North, Range 11 West, the NE¼ of section 1, Township 11 North, Range 12 West, and in the SW¼ of section 36, Township 12 North, Range 12 West, along the road from Grove Hill church and cemetery to Naborton, on the north side of the first large hill, one and one-quarter miles northeast of the church (see figs. 13, 25). The contact of the Dolet Hills sand and the underlying Chemard Lake (lignite) lentil is covered by sand float along the road but it is well exposed in the numerous adjacent gullies and ravines. The stratigraphic section exposed at the type locality is:

Paleocene Series

Midway Group

Logansport formation — Thickness

Cow Bayou member

Elevation, top of section, 357 feet (Paulin altimeter)

4. Chocolate-brown, thin-bedded, silty clays with thin,

Figure 31. Interfingering facies of Dolet Hills sand and Cow Bayou lignitic shales exposed along Kansas City Southern Railway tracks in sec. 10, T. 15 N., R. 13 W., DeSoto Parish.

gray silt layers and limonitic laminae. Weathers mottled red and gray .... 15'

Dolet Hills member

3. Fine- to medium-grained, gray to reddish-brown, massive sand (base covered) .... 100'

Naborton formation

2. Lignite and lignitic clay (Chemard Lake lentil) ... 9'

1. Gray to buff, slightly calcareous clays and silts with limonitic and calcareous concretions (base covered) .... 40'

Total thickness 164'

The section exposed along Louisiana Highway 9 in the vicinity of Rockdale church (section 6, Township 12 North, Range 12 West) shows a shale facies replacing the lower portion of the sand. The composite sequence cropping out along the road for one and one-half miles west of its junction with Louisiana Highway C-1453 is:

Paleocene Series

Midway Group

Logansport formation — Thickness

Dolet Hills member

Top elevation, 300 feet (Paulin altimeter)

7. Irregular, jointed, fine- to medium-grained, micaceous, gray to brown sand .... 40'

6. Gray, thin-bedded, argillaceous silts .... 4'

5. Gray, massive, fine-grained sands .... 3'

4. Gray, thin-bedded, argillaceous sands and silts with clay partings (gradational into overlying bed) .... 9'

3. Thin-bedded, lignitic, chocolate-brown to gray silts and silty clays .... 8'

Naborton formation

2. Lignite (Chemard Lake lentil) .... 2'6"

Figure 33. Surface concentration of limonite in lignitic shales of Cow Bayou member (Logansport formation) exposed in sec. 22, T. 13 N., R. 12 W., DeSoto Parish, along local road from Carmel to Clear Lake.

1. Gray to buff silty clays, locally calcareous (base not exposed)................................ 6"

Total thickness 67'

North of Frierson, between that town and Wallace Lake Bayou, the transitional sediments of the Dolet Hills member and the Cow Bayou member are well exposed in cuts along the Kansas City Southern Railroad in the NW$\frac{1}{4}$ of section 10, Township 15 North, Range 13 West (see fig. 31). A comparable section is exposed in the ravine one hundred yards west of the Mansfield High School both above and below the swimming pool.

On the south side of the DeSoto-Red River-Bull Bayou field, the Dolet Hills (sand) member has been deeply dissected to form the most rugged topography in either DeSoto or Red River Parish. The sand, which here attains its greatest thickness, is partially protected from erosion by the overlying lignitic clays and shales of the Cow Bayou member. In numerous places streams have cut through these lignitic beds to the underlying easily erodible sand, resulting in a rugged topography with a local relief of slightly under 200 feet. At numerous places the sands have been well cemented with both limonite and hematite. These harder layers also hold up hills and ridges. Sand float covers the lower part of all the hills in the area and makes the surface work extremely difficult.

The Dolet Hills member forms a well defined subsurface lithologic unit which can be traced from Panola County, Texas, eastward to the Red River-Bienville Parish line (see fig. 14). It varies in thickness from fifty to one hundred and twenty-five feet in this distance. It has been traced southward in the subsurface to the vicinity of Noble in Sabine Parish (see fig. 13).

The member is brought to the surface by the Logansport, Spider, Sutherlin, and Benson structures. A few outcrops of sand beneath lignitic

Figure 34. Chocolate-brown, lignitic clays with interbedded gray silts exposed in SW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 9, T. 10 N., R. 13 W., DeSoto Parish, on north side of local road. Type locality of Benson facies, Cow Bayou member of Logansport formation.

shales in the vicinity of the Holly structure probably belong to the Dolet Hills member.

Cow Bayou Member

The Cow Bayou member takes its name from Cow Bayou, a tributary of the Sabine River, in southwestern DeSoto Parish. The type locality is located in DeSoto Parish in the SE¼ of section 9 and the NW¼ of section 16, Township 10 North, Range 14 West, approximately three miles southeast of Hunter (see fig. 26). The section exposed at the type locality is:

Paleocene Series

Midway Group

Logansport formation	Thickness
Lime Hill member	
Basal elevation, 190 feet (Paulin altimeter)	
6. Gray, locally calcareous, silts and clays with large septarian concretions	25'
5. Gray to khaki, sticky, slightly silty clays with foraminifera and small mollusca	25'
4. Reddish-brown to gray silty sands and clays (transitional zone)	10'
Cow Bayou member	
3. Gray to brown, differentially indurated, jointed, fine-grained sands becoming silty in lower portion	9'
2. Dark chocolate-brown, fissile, micaceous, silts and silty clays. Arenaceous and calcareous foraminifera. Basal portion with stringers of gray sand	60'
1. Gray to brown, micaceous, slightly indurated, interbedded silty clays and fine-grained sands (base not exposed)	7'
Total thickness	136'

Figure 35. Gray to brown, micaceous, limonitic, leaf-bearing silts and clays exposed at type locality of Lula facies of Cow Bayou member (Logansport formation) in sec. 11, T. 10 N., R. 14 W., DeSoto Parish, along Louisiana Highway 747.

The relationships of the Cow Bayou member to the overlying and underlying sediments are shown by the accompanying cross sections (Figs. 13, 14, 32).

The member is transitional from the underlying Dolet Hills (sand) member. It is also transitional into the overlying Lime Hill member; the transition zone consists of five to fifteen feet of sandy and clayey, ferruginous, non-calcareous silts which weather brick-red in color.

The member consists of chocolate-brown, lignitic silts and clays with interbedded gray to brown, clays, silts and fine sands. Locally, large amounts of ferruginous materials are present. (see fig. 33). Small amounts of ferruginous materials, in the form of laminae and concretions, are present everywhere.

In the southeastern portion of the parish the member contains more sand than at the type locality and the following typical section is exposed in the northwest half of section 13, Township 10 North, Range 11 West, on the east side of Wallace Bayou:

Paleocene Series

Midway Group

Logansport formation — Thickness

Lime Hill member

Top elevation, 280 feet (Paulin altimeter)

4. Gray to brown, mildly calcareous, silts and clays with calcareous septarian concretions containing fossils .... 10'

3. Mottled red and gray sandy silts, transition zone .... 15'

Cow Bayou member

2. Light to dark gray and chocolate-brown, differ-

Figure 36. Gray, calcareous silts and clays with calcareous concretions exposed on northwest side of Louisiana Highway 180 in SW corner of sec. 23, T. 10 N., R. 11 W., Sabine Parish. Type locality of Lime Hill member of Logansport formation.

entially indurated, thin-bedded, micaceous silts, fine-grained sands, and silty clays. Cross-bedding, limonitic laminae and concretions and variable amounts of carbonaceous material present .... 27'

1. Thin-bedded, gray to chocolate-brown, fine-grained sand interbedded with silty clays. Upper portion dominantly thin-bedded, lower portion dominantly light brown in color. Variable amounts of limonitic and carbonaceous materials present .... 40'

Total thickness 92'

Westward in the area between Benson and Lula, the Cow Bayou member is divisible into two facies. The lower of these, designated as the Benson facies, consists of a wedge (?) of chocolate-brown, lignitic clays with interbedded gray silts. It carries a marine and brackish water macrofauna and microfauna. The type locality consists of exposures in a road cut on the north side of Louisiana Highway 745, 0.5 to 0.6 of a mile west of the town of Benson, in the SW¼, NE¼ of section 9, Township 10 North, Range 13 West (see fig. 34). The section exposed here is listed on page

The upper facies of the Cow Bayou member in this area, the Lula facies, is exposed near the village of Lula. It consists of forty to seventy-five feet of gray to brown, thin-bedded, micaceous, fine-grained, argillaceous sands and silts with numerous limonitic sand laminae and disc-shaped limonitic concretions. The beds are characterized by an abundance of well preserved leaves and plant fragments. The Lula facies is transitional with the underlying Benson facies. The type locality includes exposures in road cuts and gullies in the W½ of section 11, Township 10 North, Range 14 West, along Louisiana Highway 747 from one-half to one and one-half miles north of the village of Lula (see fig. 35).

The section exposed at the type locality of the Lula facies

Figure 37. Fossiliferous, septarian concretions exposed at type locality of Lime Hill member in SW corner of sec. 23, T. 10 N., R. 11 W., Sabine Parish, along Louisiana Highway 180.

in section 11, Township 10 North, Range 14 West, is:

Paleocene Series

Midway Group

Logansport formation — Thickness

Cow Bayou member

Lula facies

Top elevation, 305 feet (Paulin altimeter)

5. Weathered, gray and brown, fine-grained sands and silts	15'
4. Gray to yellow-brown, medium-bedded, to thin-bedded, cross-bedded, micaceous, differentially indurated, fine-grained sands and argillaceous silts with leaf impressions. Numerous limonitic laminae and concretions are present. The concretions are usually disc-shaped and contain excellently preserved leaf impressions	20'
3. Gray to greenish- and brownish-gray, interbedded, micaceous silts and silty clays with leaf impressions	15'
2. Gray to brown, argillaceous silts with abundant limonitic laminae and concretions. Leaf impressions	15'
1. Lignitic, purplish-brown to chocolate-brown, blocky, silty clays and silts (base not exposed)..	8'
Total thickness	73'

The section exposed along Louisiana Highway 745 for a distance of two miles west of Benson shows the relationships of the two facies. The sequence exposed here is:

Figure 38. Calcareous, siltstone lentil surrounded by gray and buff, lignitic, and slightly calcareous silts and clays exposed at Coal Bluff in sec. 17, T. 14 N., R. 10 W., Red River Parish. Lime Hill member of Logansport formation.

Paleocene Series

Midway Group

Logansport formation		Thickness
Cow Bayou member	
Lula facies	
Top elevation, 315 feet (Paulin altimeter)	
10.	Differentially indurated, gray to brown, medium-bedded, jointed, micaceous, fine- to medium-grained sands and some silts. Leaf impressions ...	20'
9.	Gray to brown, thin-bedded, micaceous, argillaceous silts. Leaf impressions	25'
Transition zone	
8.	Thin-bedded, laminated, interbedded, gray-brown and chocolate-brown, argillaceous silts with some fine-grained sands. A few leaf impressions	15'
Benson facies (Type locality)	
7.	Purplish- to chocolate-brown, slightly blocky, lignitic clays with gray silt partings. The clay weathers out into flaky, shaly particles and into a mottled red and gray, heavy soil. Marine and brackish-water foraminifera and mollusca .... (Bore hole at base of exposed section, elevation 220 feet, Paulin altimeter)	35'
6.	Chocolate-brown, silty clay with gray, micaceous partings	6'
5.	Dark gray, slightly silty clay	1'
4.	Lignite and chocolate-brown, lignitic clay	1'6"
Dolet Hills member	
3.	Light gray to brown, micaceous, silty sand	1'6"
2.	White, clean, fine-grained sand	3'
1.	Light blue-gray, fine-grained, silty sand (Bottom of hole)	2'
	Total thickness	110'

Light blue-gray,
(Bottom of hole)

Figure 39. Petrified log from Cow Bayou member of Logansport formation exposed in center of E½, sec. 18, T. 14 N., R. 13 W., DeSoto Parish. Exposed dimensions of log, 6 by 4 feet.

The Cow Bayou member has been traced on the surface and in the subsurface from Panola County, Texas, to the Red River-Bienville Parish line and from southern Caddo Parish to the vicinity of Noble in Sabine Parish (see figs. 13, 14, and plates I, II, IV). It is exposed on the surface in the central portion of this area and its base is taken as the last recorded shale in wells lying above the Dolet Hills sands. It attains a maximum thickness of slightly over two hundred feet in southern DeSoto Parish but averages between seventy-five and one hundred feet throughout most of the DeSoto-Red River Parish area (see plate VI).

The Logansport, Benson, Spider, and Sutherlin structures are each reflected as inliers of the Dolet Hills (sand) member completely surrounded by the lignitic sediments of the Cow Bayou member. Steep dips in the lignitic sediments of the Cow Bayou member also furnish evidence of the existence of the Holly and Grogan structures. An inlier of the Cow Bayou member surrounded by the Lime Hill member reflects the presence of the Pleasant Hill structural terrace.

Lime Hill Member

The Lime Hill member takes its name from Lime Hill in the SW corner of section 23, Township 10 North, Range 11 West, Sabine Parish. The type locality consists of exposures on this same hill along Louisiana Highway 180, two and one-half miles northeast of the town of Pleasant Hill (see figs. 36, 37). The section exposed here consists of thirty-five feet of interbedded, gray to brown, calcareous clays and silts with septarian concretions containing mollusks. The basal six feet of this section is lignitic and contains plant and leaf impressions. In the upper

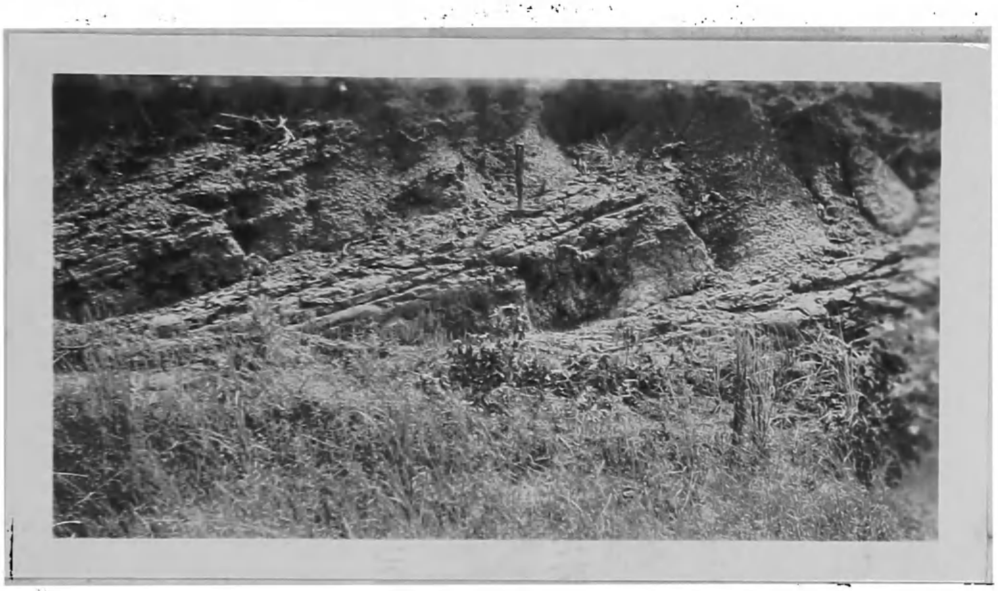

Figure 40. Cross-bedded, silty sands in Logansport formation exposed in sec. 29, T. 11 N., R. 13. W., DeSoto Parish, along U. S. Highway 171.

part of the sequence arenaceous foraminifera are numerous, calcareous foraminifera are rare. The lithology of this member maintains its characteristic features over a wide area in the Sabine Uplift region from Texas to Red River Parish. The member averages about 200 feet in thickness in DeSoto and Red River Parishes.

The exposure at Coal Bluff on Loggy Bayou (see fig. 38) in the NW¼ of section 17, Township 14 North, Range 10 West, approximately two and one-half miles northwest of the village of East Point, is the best section in Red River Parish:

Pleistocene Series

Bentley formation — Thickness

Top elevation, 235 feet (Paulin altimeter)

17. Typical Pleistocene deposits consisting of Red River clays and red, massive, cross-bedded sands overlying bedded gravels and massive sands	32'

Paleocene Series

Midway Group

Logansport formation

Lime Hill member

16. Reddish-brown, massive, porous, medium-grained sand with ferruginous "pipes" and nodules overlain by a thin bed of poorly laminated gray clays	4'
15. Massive, black lignite with blocky fracture which grades laterally upstream into lignitic clays	1-2'
14. Massive, reddish-gray, medium-grained sand separated by an irregular surface from the overlying lignite	5-10'
13. Dark brownish-gray, laminated, silty clays	1'6"
12. Massive, black lignite with blocky fracture. Grades upward and downward into lignitic clays	1'6"
11. Dark brownish-gray, laminated, silty clays which form small plates or flakes when weathered and which grade upward into lignite	2'

Figure 41. Septarian concretion from the Lime Hill member exposed near the center of sec. 16, T. 10 N., R. 14 W., DeSoto Parish, on the west side of the Hunter-Converse gravel road.

10.	Massive, porous, oxidized, yellowish-gray, medium-grained sand grading downward into clays and sands	-3'
9.	Yellowish-gray to buff, massive, fine- to medium-grained sand interstratified with fine layers of chocolate-brown clay	1'6"
8.	Massive, somewhat blocky, brownish-gray, silty clays with numerous plant fragments	1'
7.	Massive, slightly oxidized, porous, argillaceous, gray sand streaks with deep brown peaty material near the base	1-2'
6.	Poorly laminated, oxidized, yellow-brown or buff, fine-grained, sandy silt with stringers of clay	1-2'
5.	Laminated, bluish-gray, carbonaceous, gypsiferous, silty clay interfingered with small stringers of buff, fine-grained sand and with streaks of lignite. Sandy near the top	10-14'
4.	Massive, oxidized, yellow-gray to buff, argillaceous, micaceous sands and silts	6'
3.	Thin-bedded, light to dark gray, micaceous, interbedded silts and clays with stringers of fine-grained, gray sand	4'
2.	Grayish, well indurated, calcareous siltstone with plant fragments and leaf impressions	2-4'
1.	Gray, thin-bedded, micaceous, gypsiferous, interbedded silts and clays with sand lentils (base not exposed)	10'
	Total thickness	88'6" ±

Toward the northwest corner of DeSoto Parish, the proportions of sand in the Lime Hill member increases. This is evident in the section along a local road on the Texas-Louisiana line in the SE¼ of section 6, Township 13 North, Range 16 West:

Figure 42. Calcareous, septarian concretions surrounded by dark gray and brown, lignitic shales of the Lime Hill member exposed at "The Rocks" on the Sabine River in the NW$\frac{1}{4}$, sec. 3, T. 10 N., R. 15 W., DeSoto Parish.

Paleocene Series

Midway Group

Logansport formation	Thickness
Lime Hill member	
3. Interbedded, brown, limonitic sands and thin-bedded gray to brown silts (base not exposed)	10'
2. Cross-bedded, fine- and medium-grained sand with calcareous, siltstone lentils	15'
1. Mottled red and gray, thin-bedded, limonitic silts..	5'
Total thickness	30'

Lithologically similar sediments are exposed in the northern portion of DeSoto Parish near Stonewall and in southern Caddo Parish.

The Lime Hill member is transitional from the underlying Cow Bayou member (see fig. 32) and into the overlying basal sand (Loggy Bayou) member (see fig. 30) of the Hall Summit formation. The transition zone between the Lime Hill member (Logansport formation) and the Loggy Bayou member (Hall Summit formation) consists of ten to thirty feet of reddish-brown sands and clays, and ferruginous, non-calcareous silts.

The outcrop of the Lime Hill member, shown on the geologic maps (Plates I, II, and IV), covers northwestern DeSoto Parish, southeastern Caddo Parish, eastern Panola County and southeastern Shelby County, Texas, northern Sabine and Natchitoches Parishes, and western Red River Parish. The pattern of the Lime Hill-Cow Bayou contact indicates the presence of the Logansport, Benson, Grand Cane, Holly, Converse, Grogan (?), and Coushatta structural highs.

The outcrop area of the Lime Hill member is hilly, and slightly more dissected than that of the Cow Bayou member. The divides are narrow and the valleys relatively deep and steep sided. The topography in north-

Figure 43. Calcareous, siltstone lentil exposed in NE¼, sec. 8, T. 12 N., R. 13 W, DeSoto Parish, on local road north from Mansfield. Cow Bayou member of Logansport formation.

western DeSoto Parish, however, is flat and featureless.

In the subsurface, the Lime Hill member has been traced southward to the vicinity of Noble in Sabine Parish and eastward to central Red River Parish (see fig. 13). No work has been done on its subsurface relationships in Caddo and Bossier Parishes to the north, or in Shelby and Panola Counties, Texas, to the west.

Deposition of Logansport Formation

The sediments of the Logansport formation represent deposition under fluviatile, deltaic, and marine conditions. In southern DeSoto Parish, northern Sabine and Natchitoches Parishes, and in eastern Shelby County, Texas, the Lime Hill and Cow Bayou strata are deltaic with northward projecting marine sedimentary tongues. In northern DeSoto and Red River Parishes, in southern Caddo Parish, and in eastern Panola County, Texas, the Lime Hill and Cow Bayou sediments are deltaic and fluviatile. Here, intraformational conglomerates and channel sands and silts are known. Silicified wood and cross-bedding are common throughout the sediments of the formation (see figs. 39, 40). The Dolet Hills (sand) member is both fluviatile and deltaic in origin on the basis of present available information. The general lithology of the Cow Bayou member suggests deposition in a flat, coastal marsh area similar to parts of south Louisiana at the present time.

Figure 44.

Distinctive Characteristics

The strata of the Logansport formation are distinquished in their outcrop area by the following criteria:

Dolet Hills member

1. Massive sands. The sands of the Dolet Hills member are fine- to medium-grained, gray, relatively clean, massive, quartz-itic sands. Occasional silt and clay lenses are present.
2. Absence of fossils. The only organic life observed in the Dolet Hills member are rare fragments of plants or leaves.
3. Absence of well developed soils. The character of the sand of this member (largely quartz) is not conducive to soil formation. The little soil formed is always very sandy in character.

Cow Bayou member

4. Lignitic clays. Typically the sediments of this member are purplish-brown or chocolate-brown, silty clays from less than one to several inches thick separated by thin layers of gray or white silt. When weathered these sediments are dull gray to ash-gray in color. Surface induration of the lignitic clays is common.
5. Limonite. Virtually everywhere, thin, limonitic laminae and limonitic concretions are present in this member.
6. Leaves. The Cow Bayou member is notable for its numerous and excellently preserved leaves. They occur in both the lignitic clays and in the limonite concretions.
7. Soils. The soils of the Cow Bayou member are usually mottled red and gray in color. They are less sandy than the soils of

Figures 45, 50, and 51 (see pocket).

the Dolet Hills member, more so than those of the Lime Hill member.

Lime Hill member

8. Calcareous content. This is the only member of the Logansport formation with any amount of limy material. Though it is not calcareous throughout, most of its sediments contain at least a small percentage of calcium carbonate.

9. Concretions. The concretions are of several kinds: calcareous septarian concretions, calcareous non-septarian concretions, and limonitic concretions. The septarians (see figs. 41, 42) are generally one to three feet in diameter, at least partially crystalline, relatively pure, blue-gray in color, and frequently contain molluscan remains. The non-septarian, calcareous concretions (see figs. 38, 43) are discoid to round in shape, occasionally contain animal remains, almost invariably contain plant fragments, are blue-gray to brown in color, and consist of lime cemented silts with concretionary structures. All the calcareous concretions weather yellow-brown in color. The limonitic concretions are minor in size but not in number, are quite variable in shape, and occasionally contain plant remains.

10. Fossils. Both mollusca and foraminifera are locally present in the Lime Hill and Cow Bayou members of the Logansport formation. They indicate equivalency with the upper part of the Wills Point formation of Texas.

11. Soils. The soils of the Lime Hill member are, in general, reddish-gray to reddish-khaki in color, and are normally sticky and rather impervious to water. They most closely resemble

Figure 46. Interbedded, chocolate-brown shales and gray silts with numerous, well preserved leaf impressions exposed along local road in NE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 31, T. 13 N., R. 13 W., DeSoto Parish. Cow Bayou member of Logansport formation.

the soils of the Naborton formation.

12. Vegetation. The flora growing on the Lime Hill member is typically that of calcareous sediments: blue stem grass, false indigo, locusts, haws, elm, scrubby oaks, and legumes.

Paleontology

The fauna of the Logansport formation in Louisiana has not been described. LeBlanc and Barry (1941) and Murray (1941) have presented preliminary reports on the fossils present in this formation. The foraminiferal fauna is largest, the gastropod fauna next largest, and the pelecypod fauna smallest. Other fossil groups are represented by a very few species.

The commonest and most diagnostic foraminifera of the Logansport formation are: *Cristellaria midwayensis* (Plummer), *Loxostoma applinae* (Plummer), *Ammobaculites expansus* (Plummer), *Ammobaculites midwayensis* (Plummer), and *Anomalina midwayensis* (Plummer). Other species commonly found in the Logansport formation are listed in the accompanying check list (Fig. 44), which gives the distribution of these species in Louisiana and their reported distribution in Texas, Alabama, and Mississippi. The localities employed in the check list are listed in Appendix 2 along with other localities at which foraminifera have been found.

The mollusca of the Logansport formation are being described by LeBlanc and Barry in a forthcoming bulletin of the Louisiana Geological Survey. The localities employed in the accompanying check list (prepared by LeBlanc and Barry) are listed in Appendix 2 along with other localities at which mollusca have been found. The check list indicates the known occurrence of the species from Louisiana and their reported occur-

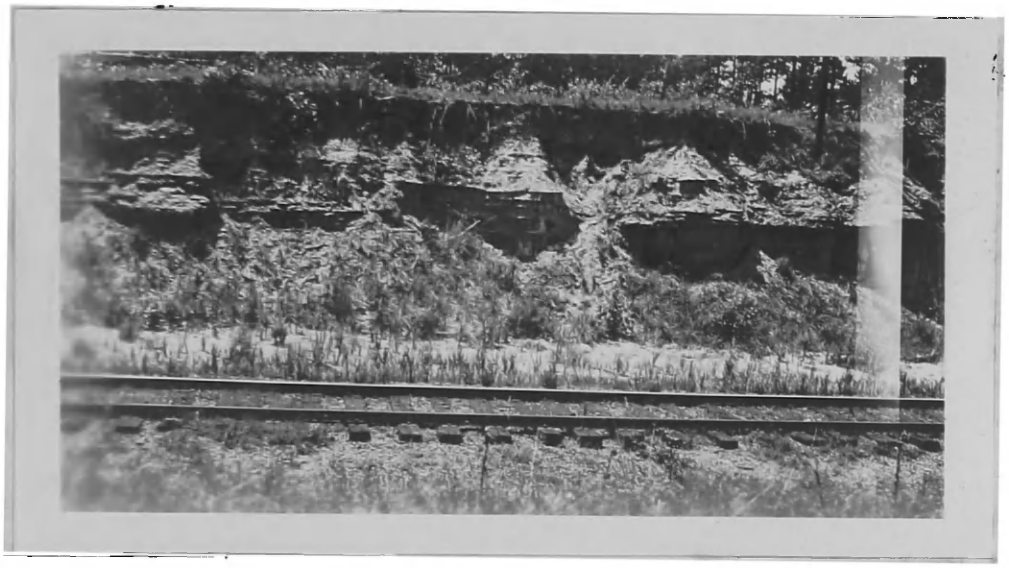

Figure 47. Chocolate-brown to gray, leaf-bearing clays and silts exposed along Kansas City Southern Railway tracks in SW$\frac{1}{4}$, sec. 3, T. 15 N., R. 13 W., DeSoto Parish, 150 yards south of trestle over Wallace Lake.

rences in other states.

Two species of ostracoda have been identified from the Logansport formation. These are: Cythereis prestwichiana Jones and Sherborn and Cytheromorpha scrobiculata Alexander. The occurrence of these species is noted on the accompanying check list of the foraminifera (see fig. 44). Other unidentified species present belong to the genera Cytherella, Cythereis, Cytheridea (Clithrocytheridea), Cytherideis, Bythocypris (?), Eucytherura, Loxoconcha, and Argilloecia (?).

A single species of bryozoa has been found. Its poor preservation prevented even generic determination.

The flora of the Logansport formation is large and varied, but little of it has been described. These fossils usually occur as impressions in lignitic clays or in clay iron concretions. Locally, impressions are abundant in lignitic, argillaceous silts and sands. Among the best localities for the collection of leaves and plants are.

1. Chocolate-brown, lignitic, clayey shales and silts exposed along local road in the NE$\frac{1}{4}$, SE$\frac{1}{4}$, of section 31, Township 13 North, Range 13 West, DeSoto Parish, two miles north northwest of Mansfield (see fig. 46).
2. Gray and chocolate-brown, lignitic, silty clays and interbedded gray silts exposed in cuts of the Kansas City Southern Railroad in the west half, SE$\frac{1}{4}$, of section 3, Township 15 North, Range 13 West, DeSoto Parish, just south of trestle over Wallace Lake Bayou (see fig. 47).
3. Chocolate-brown, lignitic, silty clays and interbedded gray silts exposed along local road on south side of Grand Cane Bayou flood plain in the N$\frac{1}{2}$, SW$\frac{1}{4}$, section 17, Township 12 North, Range 14 West, DeSoto Parish.

Figure 48. Two-foot lignite bed exposed on Louisiana bank of Sabine River in SW$\frac{1}{4}$, sec. 14, T. 10 N., R. 15 W., DeSoto Parish. Lime Hill member of Logansport formation.

4. Clays and silts constituting type locality of Lula facies of Cow Bayou member along Louisiana Highway 747 in the west half of section 11, Township 10 North, Range 14 West, DeSoto Parish, from one-half to one and one-half miles north of the village of Lula (see fig. 35). Fossils in clays, silts, and clay-limonite concretions.

Correlation

The fauna of these sediments indicates an upper Midway age for the Logansport formation (see LeBlanc and Barry, 1941, and Murray, 1941). It is tentatively correlated with the Naheola formation of Alabama and the upper part of the Wills Point formation of Texas (see fig. 23).

Economic Resources

Soils. The soils vary in fertility and degree of development. They consist of sandy and fine sandy loams; well drained upland soils; heavy, moderately permeable upland soils; heavy, slowly permeable upland soils; and heavy, slowly permeable, poorly developed upland (generally forest) soils.

The silty clays of the Logansport formation are used in the manufacture of brick. Sands and crushed calcareous concretions are used for road metal. Lignites (see fig. 48) may be of value in the future.

Hall Summit Formation

The Hall Summit formation is proposed to include all strata between the underlying Logansport formation (Midway group) and the over-

Figure 49. Mottled, brick-red and gray, argillaceous silts and clays exposed on eastern side of Louisiana Highway 404 in SE$\frac{1}{4}$, sec. 21, T. 9 N., R. 10 W., Natchitoches Parish. Transition zone between Hall Summit (Midway) and Marthaville (Sabine) formations.

lying Marthaville formation (Sabine group). It is named for exposures of lignitic shales in the vicinity of Hall Summit in Township 14 North, Range 9 West, in north central Red River Parish. No single section exposes the entire sequence which is divided into:

3. Bisteneau member (calcareous silts and clays)
2. Grand Bayou member (lignitic silts and clays)
1. Loggy Bayou member (sand)

The contact of the Hall Summit with the underlying Logansport formation is drawn at the top of the calcareous silts and clays of the Lime Hill member. The contact is nowhere sharp, but consists of a transitional zone of ten to thirty feet of interbedded, fine-grained sands and clayey silts (see fig. 30). The contact of the Hall Summit formation with the overlying basal sands of the Marthaville formation (Sabine Eocene) is also transitional (see fig. 49). It is drawn at the top of the calcareous clays and silts of the Bisteneau member.

The Hall Summit formation crops out in a belt from the vicinity of Lake Bisteneau southeastward across central Red River Parish. Near the southeast corner of Red River Parish the coutcrop belt turns southwestward, swings across northwestern Natchitoches and Sabine Parishes to the Sabine River, and extends westward into Shelby County, Texas. It does not crop out in DeSoto Parish. The outcrop area forms an irregularly circular belt around the top of the Sabine Uplift (see geologic maps, plates II and IV).

The formation, on the basis of surface and subsurface studies, has a maximum thickness of slightly over three hundred feet in Sabine Parish. Elsewhere it averages about two hundred feet in thickness.

The outcrop belt of the Hall Summit formation is rather flat and featureless. In Red River Parish, where it was originally covered by deposits of the Bentley or Williana formation, the topography is gently

Figure 52. Calcareous concretion containing numerous *Ostrea thirsae* Gabb exposed in railroad cut 50 yards east of depot in town of Marthaville, Natchitoches Parish.

rolling and there are few good exposures.

Loggy Bayou Member

The Loggy Bayou member takes its name from Loggy Bayou, a rim-swamp stream on the eastern edge of the Red River flood plain, in Red River Parish, Louisiana. The type locality consists of exposures at and in the vicinity of Yellow Bluff in the NW$\frac{1}{4}$ of section 8 and the SW$\frac{1}{4}$ of section 5, Township 14 North, Range 10 West, near the junction of Love Lake and Loggy Bayou. The stratigraphic section exposed at the type locality consists, at low water, of twenty-three feet of gray to buff, fine- to medium-grained, slightly cross-bedded, micaceous sand overlain by Pleistocene deposits of the Bentley formation.

The Loggy Bayou member consists of twenty to sixty feet of gray to brown, fine- to medium-grained, usually ferruginous sand. In western Sabine Parish some glauconite is present in the sand in the area west of Noble. It conformably overlies and is transitional from the underlying Lime Hill member of the Logansport formation. A similar stratigraphic relationship exists with the overlying Grand Bayou member. It crops out from the vicinity of the Sabine River northeastward across Sabine and Natchitoches Parishes to the Red River flood plain. Then it swings northwestward across Red River Parish to the Red River flood plain in the northwest-central portion of the parish. It has not been differentiated in the subsurface.

Because it is not differentiated on the geologic maps, the following exposures are listed: (1) underlying Pleistocene deposits in sections 4, 5, 8, and 9, Township 14 North, Range 10 West, Red River Parish; (2) along Louisiana Highway 9 near the center of the line between Townships

Figure 53. Pleistocene (Bentley) terrace gravels overlying basal sand member of Marthaville formation in SW$\frac{1}{4}$, sec. 30, T. 13 N., R. 9 W., Red River Parish.

12 and 13 North, Range 9 West, Red River Parish; (3) along Louisiana Highways 1 and 51 approximately one mile north of Belmont, in sections 28 and 29, Township 9 North, Range 11 West; (4) along Louisiana Highway 404 in section 3, Township 9 North, Range 10 West, and section 34, Township 10 North, Range 10 West, in the vicinity of Beulah church, Natchitoches Parish; (5) along Louisiana Highway 42E in section 36, Township 9 North, Range 13 West, Sabine Parish, about two and one-half miles north-northwest of Noble; and (6) along local roads in sections 35 and 36, Township 9 North, Range 14 West, and sections 1 and 2, Township 8 North, Range 14 West.

Grand Bayou Member

The Grand Bayou member is defined as the middle member of the Hall Summit formation. It is transitional with the overlying Bistenau member and the underlying Loggy Bayou member. It consists of thirty to eighty feet of gray to chocolate-brown, usually lignitic, clays and silts with occasional lenses of fine-grained sand. The type locality is designated to consist of exposures in sections 19, 20, 29, and 30, Township 14 North, Range 9 West, Red River Parish, Louisiana. The exposures of this area, though rather poor, are chosen for the type locality because of the proximity to the stream from which the name is derived. The following sequence, penetrated by a hand-dug water well in the SE corner, SW$\frac{1}{4}$, SW$\frac{1}{4}$ of section 21, Township 14 North, Range 9 West, on the north side of Louisiana Highway 99$\frac{1}{2}$ in the town of Hall Summit, typifies better than surface exposures the lithology of this member:

Figure 54. Purplish-red, calcareous clays of Bentley formation exposed in sec. 5, T. 14 N., R. 10 W., Red River Parish, along U. S. Highway 71.

Paleocene Series

Midway Group

Hall Summit formation — Thickness

Grand Bayou member

Top elevation, 210 feet (Paulin altimeter)

4. Mottled, red and gray, heavy soil..................	2'
3. Light to dark gray, micaceous, lignitic, interbedded clays and silts	15'
2. Gray, fine-grained sand	4'
2. Gray, fine-grained sand	17'
1. Dark gray to chocolate-brown, lignitic silts and clays (base not exposed)	38'

In the $SW\frac{1}{4}$, $NE\frac{1}{4}$, $SW\frac{1}{4}$, of section 19, Township 14 North, Range 9 West, borings penetrated thirty-two feet of chocolate-brown and dark gray, micaceous, interbedded silts and clays. Similarly, water well borings in the $SW\frac{1}{4}$, $NW\frac{1}{4}$, of section 30, Township 14 North, Range 9 West, penetrated twenty-eight feet of chocolate-brown, lignitic, micaceous, interbedded clays and silts belonging to this member. Because the Grand Bayou member is not differentiated on the map, the following good exposures are listed: (1) in sections 34 and 35, Township 13 North, Range 9 West, Red River Parish, along Louisiana Highway 9; (2) in section 10, Township 9 North, Range 10 West, Natchitoches Parish, along Louisiana Highway 404 north of Marthaville; (3) along Louisiana Highways 1 and 51 in sections 32 and 33, Township 9 North, Range 11 West, Sabine Parish; and (4) along Louisiana Highway 42E one mile north of Noble in section 2, Township 8 North, Range 13 West, and section 35, Township 9 North, Range 13 West.

The outcrop belt of the Grand Bayou member extends from Shelby County, Texas, northeastward across Sabine and Natchitoches Parishes to the southeastern corner of Red River Parish. It then swings northwest-

Figure 55. Pleistocene (Prairie) terrace gravels overlying gray, calcareous clays of Lime Hill member of Logansport formation in NE¼, sec. 32, T. 13 N., R. 9 W., Red River Parish.

ward across central Red River Parish to the Red River flood plain in Township 14 North, Range 10 West. In northern Red River Parish the Grand Bayou member apparently interfingers with and is replaced by the calcareous sediments of the Bisteneau member.

No studies have been made of this member in the subsurface.

Bisteneau Member

The* Bisteneau member is defined as the upper member of the Hall Summit formation. It includes all sediments stratigraphically between the Grand Bayou member of the Hall Summit formation and the overlying basal sand of the Marthaville formation. These beds are conformable with and transitional into the overlying and underlying sediments. The Bisteneau member consists of twenty-five to one hundred feet or more of interbedded, calcareous and non-calcareous, often micaceous, gray to buff silts, clays, and occasionally fine-grained sands. Locally, gray or light chocolate-brown, lignitic silts and clays are present. Glauconitic strata occur in western Sabine Parish in the area between Noble and the Sabine River. Numerous, large, calcareous siltstone and calcareous septarian concretions are found throughout the outcrop area.

Exposures in Township 15 North, Range 10 West, in southwestern Bienville Parish, constitute the type locality. A well exposed section occurs in sections 9 and 10, Township 15 North, Range 10 West, Bienville Parish, along the new gravel road from Ringgold to Lake Bisteneau (Louisiana Highways 565D, 933, and 1154). The sequence exposed here is (after lithology by R. D. Russell):

Figure 56. Purplish-red, calcareous clays of Prairie formation exposed in gulley in SE¼, sec. 32, T. 13 N., R. 9 W., Red River Parish, on east side of Grand Bayou.

Paleocene Series

Midway Group

Hall Summit formation — Thickness

Bisteneau member

18.	Thin-bedded, almost platy silts with clay partings, weathering yellow-brown	8'
17.	Covered	22'
16.	Thinly laminated, medium-grained, gray and brown silts with clay partings. Many of clay partings are lignitic with leaf fragments. Beds of coarse silt or very fine sand up to two inches in thickness in upper part	8'
15.	Brown, lignitic, clay shale with nodular weathering. Effluorences of sulfur locally present	18'
14.	Fine-grained; clayey silt with poor fossil leaf impressions, weathering pale yellow-brown to nearly white with yellow and brown spots of limonite. (Base not exposed)	2'
13.	Platy, lignitic clays (in part covered)	10'
12.	Like No. 13 but more silty and weathering in pure gray to yellow-brown bands. Calcareous concretions up to four feet by three feet in dimensions	8'
11.	Lignite. Lenses out to west	3"
10.	Hard, platy, fine-grained, highly lignitic, dark brown to black in color which weathers chocolate-brown to pale greenish-gray	2'
9.	Pale, greenish-gray, medium- to fine-grained sand with some medium to coarse silt. Bluish-gray partings of clay up to one inch thick. Lignitic fragments. Weathered bands yellow-brown and blue-gray in color	7'
8.	Covered	6'
7.	Platy, somewhat lignitic, silty clay shale. Weathers pale greenish-yellow with limonitic streaks	4'
6.	Fine- to coarse-grained silt, platy towards top	

and becoming more massive towards base. Coarser layers are cross-bedded. Partings and thin beds of lignitic, silty clay and a few stringers of nearly pure lignite are present. Limonitic stringers up to six feet long and a few inches thick and numerous calcareous concretions from one to ten feet in diameter are present. Lenses out to west .... 14'

5. Platy, fine-grained, somewhat lignitic, clayey silt to silty clay with leaf fragments .... 10'

4. Thinly bedded but not laminated, very fine, clayey silts to medium-coarse silts with small amounts of lignitic material on bedding planes .... 10'

Grand Bayou member (?)

3. Lignitic clay shales with lenticular beds of lignite up to four inches thick .... 12'

2. Covered .... 8'

1. Lignitic, chocolate-brown to dark gray, clay shale with nodular weathering and thinly bedded, medium-grained silt with clay partings. Thin-bedded silts show up to thirty degree dips which are apparently slumping or possibly faulting ...... 6'

Total thickness 155'3"

A bluff on the west side of the Grand Bayou flood plain in the NE¼ of section 5, Township 14 North, Range 9 West, exposes the following sequence and illustrates the relationships between the Bisteneau member and the overlying basal sand member of the Marthaville formation:

Eocene Series

Sabine Group

Marthaville formation | Thickness

3. Gray to buff, slightly cross-bedded, micaceous fine- to medium-grained sand .... 20'

Paleocene Series

Midway Group

Hall Summit formation	Thickness
Bisteneau member	
2. Gray to buff, thin-bedded silts and fine-grained sands with large, lenticular, siltstone ledge. (Base not exposed)	5'
1. Gray, lignitic, thin-bedded, silty clays. (Base not exposed)	10'
Total thickness	35'

The outcrop of the Bisteneau member extends from Shelby County, Texas, northeastward across Sabine and Natchitoches Parishes to the southeastern corner of Red River Parish. It then swings northwestward across the central portion of the parish in irregular fashion to the vicinity of Hall Summit. The outcrop pattern widens from here north and west, due, in part, to its partial replacement of the lignitic facies of the Grand Bayou member, and in part, to structure. It crops out over the greater portion of the southwest corner of Bienville Parish. The member has not been studied in the subsurface.

Deposition of Hall Summit Formation

The sediments of the Hall Summit formation indicate deposition under fluviatile and deltaic conditions. The irregularity and lenticularity of the sands and silts denotes fluviatile (channel and levee) deposition. The lignitic, non-fossiliferous, character of the deposits suggests floodplain swamp conditions; and, large amounts of calcareous material in Bienville Parish, as well as locally abundant glauconitic strata with fossils in Sabine Parish, suggest deltaic or paludal deposition.

Distinctive Characteristics

The most important criteria for differentiating the Hall Summit formation are as follows:

1. Glauconite. The Hall Summit formation is the oldest Tertiary formation present on the surface in Louisiana that carries any appreciable quantity of glauconite. A small amount of glauconite is present in some of the Tertiary sediments below the Hall Summit formation but nowhere in Louisiana in stratigraphically lower Tertiary sediments is this mineral common.
2. Concretions. The concretions of the Hall Summit formation are dominantly calcareous siltstone concretions of very large size. Only a few calcareous septarian concretions were observed in these strata. Frequently, limonite concretions of various sizes and shapes are present.
3. Limonite. The limonite of the Hall Summit formation is particularly prominent in two forms: (1) as thin laminae and (2) as concretionary structures of various shapes and sizes. More limonite is found in the Grand Bayou member than in any other part of the formation.
4. Soils. The soils of the Loggy Bayou member are similar to those of the Dolet Hills member of the Logansport formation. They are sandy, silty, loamy, and poorly developed. The Grand Bayou soils are very similar to those of the Cow Bayou member of the Logansport formation. They are generally mottled, heavy, red and gray, and easily eroded. The Bisteneau soils resemble those of the Lime Hill member of the Logansport forma-

tion and those of the Naborton formation. They are reddish-gray to reddish-khaki in color, heavy, colloidal, and easily eroded.

5. Absence of fossils. At only one locality in the Hall Summit formation have fossil remains of animals been found. Plant fossils were found at only a few localities. Thus this formation constitutes a sequence of essentially unfossiliferous strata between the fossiliferous upper Logansport and the Marthaville formation.

Paleontology

The fossil remains of animal organisms are represented by a single species, Anomia rufa Barry (Manuscript). Well preserved plant remains were found at but one locality. Poorly preserved leaves and plant fragments are present at several places in the lignitic strata of the Grand Bayou and Bisteneau members and in the calcareous concretions of the Bisteneau member.

The locality from which the Anomia was obtained is in the center of section 12, Township 9 North, Range 14 West, along a local dirt road. The single excellent fossil leaf locality is on the east side of a creek in the NW¼, SW¼, of section 13, Township 13 North, Range 9 West, Red River Parish, in road cuts on the south side of Louisiana Highway 792.

Economic Resources

On outcrop, the only economic resources of the Hall Summit formation are its soils. Quite likely downdip equivalents of the formation may be productive of oil and gas.

Eocene Series

Sabine Group

Introduction

The sediments of the Sabine group are very similar in character to the upper Midway surface sediments (see figs. 50, 51, plate V) and consist of recurrent alternations of sand, lignitic shale, and calcareous silts and clays with locally abundant glauconite. Tongues of marine deposits contain fossils which definitely date the sequences.

Three sequences or alternations of Sabine sediments are known to exist from reconnaissance mapping by members of the Louisiana Geological Survey. The lower sequence is raised to formational rank; the two upper sequences, because of insufficient field evidence, are designated units in this report. No deposits of Sabine age crop out in DeSoto Parish. In eastern Red River Parish, however, approximately 100 feet of sediments belonging to the lowermost of the Sabine sequences are known to crop out (see fig. 14, plates II and IV).

Sabine deposits in Red River Parish have not been named and it is necessary, therefore, to name these beds of the lowermost sedimentary sequence. The name Marthaville formation is proposed to include the basal Sabine sedimentary sequence which locally carries a Nanafalia (basal "Wilcox") fauna. These beds overlie the Hall Summit formation (uppermost Midway) and underlie younger Sabine sediments. Marthaville, in Sabine Parish, Louisiana, is designated as the type locality (see map, plate IV and figs. 49, 50, 51, 52) because: (1) it is a well known Louisiana Sabine fossil locality, (2) the name Marthaville has been used in the literature, and (3) fossils present in these sediments are characteristic of the basal Sabine ("Wilcox") sediments from Alabama to Mexico.

The Marthaville formation is transitional from the underlying Hall Summit formation (see fig. 49) and into the overlying Pendleton unit.

The lithologic sequence included in the Marthaville formation has been traced on the surface across northern Natchitoches Parish into Red River Parish (see geologic maps, plates II and IV).

Overlying the Marthaville formation in the Sabine Uplift area are two sedimentary sequences carrying distinctive faunas (LeBlanc and Barry, 1941). These are the Pendleton (lower) and Sabinetown (upper) faunal units. On the basis of fauna, the Pendleton unit is correlated with the Tuscahoma formation of Alabama, the Sabinetown unit with the Bashi formation (see correlation chart, fig. 23). The stratigraphic relationships of these units are shown on fig. 51. Their generalized outcrop areas are indicated on the regional map (Plate IV).

Veatch (1905, 1906), Howe and Garrett (1934), Howe (1933, 1936), and LeBlanc and Barry (1941) have discussed the nomenclature of the Sabine group. Howe and Garrett (1934) divided the Sabine group into (1) the Wilcox sub-group, including sediments stratigraphically below the Claiborne group and above the base of the Ostrea thirsae zone, and (2) the Mansfield sub-group, including sediments stratigraphically below the *Ostrea thirsae* zone and above the "Midway black shales". LeBlanc and Barry have presented evidence for drawing the base of the Sabine group in Louisiana at the base of the *Ostrea thirsae* - *Ostrea multilirata* zone. In this report the base of the Sabine group is drawn at the base of the lithologic sequence (Marthaville formation) that contains the *Ostrea thirsae* - *Ostrea multilirata* zone since *Ostrea thirsae* has been found in the basal sand of this sequence. The relationships of this Sabine-Midway contact are shown in fig. 51.

Marthaville Formation in Red River Parish

In Red River Parish the Marthaville formation includes a basal sand, a middle lignitic shale, and an upper calcareous unit. Because the Marthaville sequence in this area consists only of small isolated exposures cropping out beneath terrace gravels, no attempt has been made to subdivide the formation into members.

The basal sand, approximately 50 feet thick, is fine- to medium-grained, cross-bedded, micaceous, argillaceous, silty, and limonitic. It is best exposed in the SE¼, section 30, the SE¼, section 25, and the NW¼, section 36, Township 13 North, Range 9 West (see fig. 53).

The shale unit is lignitic, gray to chocolate-brown, micaceous, thin-bedded, and generally interbedded with gray silts. It is best exposed in Red River Parish in the SW corner, NE¼, section 6, Township 13 North, Range 9 West, underlying the Montgomery formation along Louisiana Highway 225. A water well in the center of the SW¼, section 22, Township 13 North, Range 8 West, on the north side of Louisiana Highway 9, penetrated 28 feet of this chocolate-brown shale beneath the deposits of the Montgomery formation. Many other exposures of the lignitic shales crop out beneath Pleistocene deposits in Township 14 North, Ranges 8 and 9 West, in the area between Louisiana Highway 225 and Black Lake Bayou. The shale unit is transitional into the underlying sands and overlying calcareous silts and clays.

The upper calcareous unit consists of thin-bedded, buff to gray, micaceous, slightly calcareous silts and clays with thin, limonitic, silty laminae and calcareous concretions. These sediments are well exposed on the west side of the Black Lake Bayou flood plain in Township 13 North, Range 8 West.

Paleontology and Correlation

Harris (1899), Howe and Garrett (1934), and LeBlanc and Barry (1941) have described the faunas of the Marthaville formation and indicated its equivalence to the Nanafalia formation of Alabama (see correlation chart, fig. 23). No animal fossils are known to exist in the Marthaville formation in Red River Parish. Occasional plant fragments have been observed in the lignitic shales in this parish.

Quaternary Sediments

Pleistocene Series

Introduction

Quaternary deposits consisting of four Pleistocene sedimentary sequences and Recent alluvium unconformably overlie the Tertiary deposits of DeSoto and Red River Parishes (see figs. 53, 54, 55). Fisk (1938) first mapped the Williana, Bentley, Montgomery, and Prairie terrace surfaces, as such, in Louisiana. In 1940, he elevated the sedimentary sequences underlying the terrace surfaces to the rank of formations. The areal extent of the Quaternary formations in these parishes is shown on the accompanying geologic maps (Plates I and II).

Pleistocene Series

Williana Formation

The only deposits of the Williana formation in these parishes are exposed in section 25, Township 11 North, Range 15 West, one mile northwest of Hunter, in DeSoto Parish. The sediments consist of loose, coarse- to medium-grained, quartz sand with numerous chert gravels. The basal elevation of this deposit is approximately three hundred and sixty feet. It reaches a maximum thickness of fifty feet.

Residual gravel of questionable Williana age also occur in a northwest-southeast trending belt from Oak Grove school in section 3, Township 11 North, Range 15 West, to Lula.

Bentley Formation

The Bentley formation in DeSoto Parish occupies the divide areas between the tributaries of the Sabine River. The deposits consist of a sequence of basal sands and gravels grading upward through silts into silty clays. The gravel facies are best developed and best exposed in the center of Township 11 North, Range 15 West, in the vicinity of Rocky Branch. Bentley deposits are highly oxidized and have a typical dark-red color; limonitic cementations of coarse sands and gravels are very common.

The Bentley deposits of Red River Parish crop out in belts parallel to the Red River and to Black Lake Bayou. The deposits in both of these belts consist of sedimentary sequences grading upward from basal gravels and sands through silts into calcareous clays (see fig. 54).

The Bentley formation in DeSoto Parish attains a maximum thickness of 75 feet but averages about 40 feet. In Red River Parish it has a maximum thickness of 125 feet.

Gravel facies of the Bentley formation furnish gravel for roads in the Hunter area of DeSoto Parish and in eastern Red River Parish. A report on the commercial aspects of these gravel deposits has been published by the Louisiana Geological Survey (Woodward and Gueno, 1941).

The sequence of the Bentley formation encountered in the L. Decker, Tr., Long Bell-Madden No. 1 well, section 21, Township 14 North, Range 10 West is:

Pleistocene Series	Thickness
Bentley formation	
Silt and clay	30'
Hard clay, sand, gravel, and lignite	61'
Sand and gravel	18'
Sand rock	2'
Total thickness	111'

The soils of the Bentley formation belong in large part to the groups of well drained upland soils. Ruston is perhaps the most characteristic of the Bentley soils, but locally Bowie, Sawyer, and Shubuta are common.

Montgomery Formation

The Montgomery formation in DeSoto Parish crops out from south of Logansport northwestward into Texas. It consists of basal sands and gravels grading upward into silts and clays. The sediments vary from orange to gray and attain a maximum thickness of 100 feet.

The Montgomery sediments in the western portion of Red River Parish were deposited by the ancestral Red River. They vary from gray through orange and reddish-brown to purplish-red on the outcrop. The sediments consist of basal sands and gravels that grade upward through silts into calcareous clays. The Montgomery deposits of Red River origin thicken southward from northern Red River Parish (maximum thickness, 85 feet) to the Red River-Natchitoches Parish line (maximum thickness, 125 feet).

The Montgomery deposits of eastern Red River Parish were deposited by an ancestral stream of the modern Black Lake Bayou. They consist of gray to red sands and gravels grading upward through silts into clays. No calcareous deposits of Montgomery age are known to exist in this outcrop area. Gravel facies are economically exploited for road metal in the area of Townships 13 and 14 North, Range 8 West. Woodward and Gueno (1941) have presented the economic aspects of these deposits.

The Montgomery deposits of Black Lake Bayou origin vary from a few feet to a maximum of 60 feet in thickness. Lenticularity of the deposits, plus cross-bedding, rounding, and orientation of the gravels indicate a fluviatile origin for all these Montgomery deposits.

A typical section of the Montgomery formation is encountered in the Gulf Refining Co., Ideal Land Co. well No. 1, section 21, Township 13 North, Range 10 West, Red River Parish. It is:

Pleistocene Series	Thickness
Montgomery formation	
Clay	30'
Sand	20'
Sand and gravel	60'
Total thickness	110'

The soils of the Montgomery formation are classed as Coastal Plain* and Red River terrace soils and as upland soils. Where dissection has been prevalent, they are generally classed as upland soils; where the flatness of the surface has been preserved, they are generally classed under terrace soils. Those soils developed on Montgomery sediments deposited by the ancestral Red River are grouped as Red River terrace soils; those developed on sediments deposited by the ancestral Sabine River or by the ancestral Black Lake Bayou are classed as Coastal Plain terrace soils.

Prairie Formation

The largest exposure of the Prairie formation in this area crops out in northeastern DeSoto Parish. Smaller outcrops are known bordering the Sabine River, Grand Cane Bayou, Clement Bayou, Cow Bayou, and Wallace Bayou in DeSoto Parish, and bordering the Red River, Grand Bayou, and Black Lake Bayou in Red River Parish (see geologic maps, plates I and II).

The deposits of Red River origin vary from white to purplish-red

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*The term Coastal Plain terrace is used by soil technicians of the Soil Conservation Service in northwestern Louisiana to refer to terraces underlain by reworked Coastal Plain deposits (Tertiary and Cretaceous). They use the term Red River terrace to refer to terraces underlain by reworked Permian red bed sediments.

and consist of basal sands and silts grading upward into calcareous silts and clays (see fig. 56). Frequently, small lime nodules are abundant on the outcrop. In northeastern DeSoto Parish, the Red River Prairie sediments interfinger with the sediments comprising the Prairie formation along Vacherie and Fordoche Bayous (composed of reworked Tertiary sediments). Soil technicians in this area have differentiated these sediments and have mapped the contact between them.

The Prairie deposits not of Red River origin are almost invariably gray or light orange-brown. They consist of the usual sequence of basal sands and gravels grading upward through silts into clays. No calcareous materials are known to occur in these deposits.

The Prairie formation attains a maximum known thickness of 118 feet. A boring for a seismograph survey penetrated 93 feet of Prairie sediments in the NW corner, section 5, Township 13 North, Range 11 West, DeSoto Parish, before passing into Tertiary sediments. The top of the hole was 25 feet below the surface of the Prairie terrace. A series of such holes along Louisiana Highway 146 between Clear Lake and Bayou Pierre River penetrated from 80 to 100 feet of Prairie sediments. Southwest of Clear Lake the thickness of the Prairie rapidly drops to between 40 and 50 feet as the edge of the Prairie valley is approached.

The sequence penetrated by the seismograph boring in section 5, Township 13 North, Range 11 West, DeSoto Parish, is typical of the Prairie formation of Red River origin. It is:

Pleistocene Series	Thickness
Prairie formation	
Red-brown, interbedded silts and clays	15'
Red-brown silts and fine-grained sands with calcareous nodules in the lower 6 feet	31'

Red-brown to gray, medium-grained sand................	6'
Red-brown and gray, medium- to coarse-grained sand with small gravel	23'
Red-brown to gray, coarse-grained sands with gravel ..	18'
Total thickness	93'

Borings through the Prairie formation bordering the Sabine River indicate a thickness as great as 90 feet for these deposits. Elsewhere the Prairie formation varies from 40 to 75 feet in thickness.

The soils of the Prairie formation form its most important economic resources. They consist of Red River and Coastal Plain terrace soils.

Recent Alluvium

The Recent alluvial deposits of DeSoto and Red River Parishes consist of sediments derived from (1) the Permian basin area of north Texas and south Oklahoma, and, (2) the Cretaceous and Tertiary deposits of the Gulf Coastal Plain.

The reworked Permian materials dominate sediments carried by the Red River, and impart to them a characteristic brownish-red to purplish-red color. These Recent "red beds" fill the modern valley of the Red River through western Red River and eastern DeSoto Parishes, and extend some distance up the larger tributary valleys. Typically, the Recent Red River alluvium consists of basal sands and gravels grading upward into finer sediments deposited in back swamps, levees, and channels. The Recent Red River alluvium is slightly calcareous and, in particular, the backswamps clays contain concentrations of lime nodules.

The Recent alluvium of the Red River valley attains a maximum known thickness of 280 feet. Near the valley walls this thickness decreases to but a few feet. The thicknesses of alluvium encountered in several hundred borings for oil and gas in the DeSoto-Red River Parish portion of the Red River valley have been tabulated for each township of the flood plain. The ranges in thickness for these areas are:

Area	Thickness
Township 15 North, Range 12 West	70-121'
Township 14 North, Range 11 West	80-160'
Township 14 North, Range 12 West	80-130'
Township 13 North, Range 10 West	55-176'
Township 13 North, Range 11 West	46-178'
Township 12 North, Range 10 West	65-214'
Township 12 North, Range 11 West	48-200'

The thicknesses, when tabulated well by well, indicate at least two common depths of alluvium, 70 to 80 feet and 105 to 125 feet. Just what interpretation should be applied to these different alluvial thicknesses is unknown. They may subsequently prove to be connected in some way with the disappearance of the ice at the close of the Pleistocene.

Alluvial deposits of the Sabine River and Black Lake Bayou and their tributaries are dominated by Cretaceous and Tertiary materials derived from the Gulf Coastal Plain. The Sabine River deposits attain a maximum known thickness of slightly over 100 feet near the DeSoto-Sabine Parish line. The Grand Bayou and Black Lake Bayou alluvium reaches a maximum known thickness of 75 feet. Alluvial deposits laid down by the smaller streams in DeSoto and Red River Parishes vary in thickness from a few feet near their headwaters to thicknesses in the lower portion of their course comparable to those for the alluvium of the master stream.

The soils of the Recent alluvial deposits constitute their most important economic resource. These soils belong to the Red River and Coastal Plain groups of alluvial soils. The best drained soils of these groups are developed on natural levees and are the most productive soils in DeSoto or Red River Parish. The poorly drained alluvial soils are seldom used except for pasturage or forest.

STRUCTURE

Sabine Uplift

The Sabine Uplift is a flat-topped dome approximately 80 miles long and 65 miles wide situated in northwestern Louisiana and northeastern Texas. Harris (1907, 1910) named and defined the uplift. Veatch (1906 B), and Matson (1916), Matson and Hopkins (1918), Dumble (1920), Powers (1920), Huntley (1923), and Moody (1931) have presented additional information on the structure and outline of the uplift area.

Powers described the uplift from subsurface contours drawn on the Nacatoch sand. He showed two major axes of warping, one northwest-southeast, the other at right angles to this. Contours drawn on the base of the lower Cretaceous Ferry Lake Anhydrite by Spooner (1939) indicate that the uplift is slightly "pear-shaped" in outline, the long dimension approximately north-northwest by south-southeast. The flat top of the uplift is broken by numerous small domes, anticlines, basins, and synclines. The highest structural part of the dome in the lower Cretaceous (see Spooner, 1939) is the Caddo field of northern Caddo Parish (2,500 feet subsea). The structurally highest (except for salt domes) upper Cretaceous sediments are in the Caddo and DeSoto-Red River-Bull Bayou areas where the Nacatoch sand is approximately 500 feet below sea level (Huntley, 1923).

Surface mapping in northwestern Louisiana indicates that the DeSoto-Red River-Bull Bayou uplift is the highest structural portion of the Sabine Uplift when mapped on the Tertiary (see regional map, plate III; also Moody, 1931). The Naborton formation, which crops out as an inlier reflecting this uplift on the surface, is completely surrounded by younger sediments. All Midway and Sabine sediments younger than the Naborton formation encircle the DeSoto-Red River-Bull Bayou uplift. These younger sediments outline both the Sabine Uplift and many of the smaller structural features on its crest and flanks.

The youngest sediments for which there is positive field proof of complete coverage of the uplift belong to the Logansport formation. However, the existence of marine lentils on all sides of the uplift in upper Midway, Sabine, and Claiborne sediments indicates that the area of the modern Sabine Uplift was actively receiving sediments until the close of the Claiborne. On the other hand, no evidence has been found to indicate whether uplift was taking place at a slower rate than the rate of sedimentary accumulation. Some pre-Gulf series uplift occurred in this area as indicated by the unconformable upper Cretaceous-lower Cretaceous contact.

On the basis of evidence from structural deformation the final uplift of this area apparently was associated with Miocene sedimentation. As pointed out by Fisk (1937, 1940), Miocene deltaic sedimentation centered in south-central Louisiana. Subsidence and resultant down-dragging of this and adjacent areas accompanied and followed the accumulation of this great deltaic mass. The more or less equal deformation of the pre-Miocene sediments along the Angelina-Caldwell monoclinal flexure (flanking in part the south side of the Sabine Uplift) suggests that the flexure may be largely a result of the downwarping associated with Miocene deposition. The Sabine Uplift may be a result of subcrustal movements associated with the subsidence beneath thick Miocene sediments to the south. The accumulation of the Paleocene, the Wilcox, and the Claiborne deltaic masses, which flank the uplift on the southeast and southwest probably also affected the position, shape, and elevation of the Sabine

Uplift.

The origin of the small domes and anticlines on the Sabine Uplift is unknown. On the basis of their structural similarity to salt domes in areas to the south, east, and west, they may be due to deep-seated salt intrusions. Though no boring in DeSoto or Red River Parishes has yet encountered salt, borings for oil and gas and the existence of salt domes near the surface prove the presence of thick salt beds on all sides of the uplift and suggest their probable existence across the entire uplift.

Structure of DeSoto and Red River Parishes

The structure of DeSoto and Red River Parishes is shown on the subsurface contour map (Plate VII) which is drawn on the base of the Ozan chalk (Gulf Cretaceous). This map shows the numerous small domes, anticlines, basins, and synclines surrounding the large DeSoto-Red River-Bull Bayou domal uplift, the highest structural feature in the DeSoto-Red River Parish area. The Gulf Cretaceous deposits dip from 25 to 150 feet per mile away from the center of the structural highs.

The majority of the structural highs present in the Gulf Cretaceous deposits of DeSoto and Red River Parishes are reflected on the surface (see maps, plates I, II, IV). The DeSoto-Red River-Bull Bayou field of DeSoto and Red River Parishes is reflected on the surface as an inlier of the Naborton formation completely surrounded by sediments of the Logansport formation. The Sutherlin, Spider, Benson, and Logansport highs of DeSoto Parish are reflected as inliers of the Dolet Hills (sand) member surrounded by lignitic shales of the Cow Bayou member. The Pleasant Hill field of DeSoto and Sabine Parishes shows up on the surface as an inlier of the Cow Bayou member (lignitic shales) surrounded by the deposits of the Lime Hill member (calcareous silts and clays). The Grand Cane and Holly structures of DeSoto Parish, and the Coushatta and Lake End structures of Red River Parish, are obvious from a study of local strikes and dips, topography, and outcrop patterns.

A structural high between Mansfield and Carmel is represented by the appearance of the Naborton formation on the surface northwest of its normal outcrop area. The Chemard Lake (Grogan and Ramsey) structural nose, in southeastern DeSoto Parish, swings the normal outcrop area of the Naborton formation far to the southeast. Steep dips in the Tertiary sediments north of Frierson reflect the existence of the Caspiana and Elm Grove structures. Similarly, the major synclines of the two parishes are mappable on the basis of the differentiated lithologic units.

PETROLEUM GEOLOGY

Introduction

The first discovery of oil and gas in northwestern Louisiana was in the Caddo field, Caddo Parish, in 1904. Many large producers were drilled in that area and as a result exploration for oil and gas spread rapidly into adjacent areas. The first commercial gas well in the DeSoto-Red River Parish area was completed in 1912, the first commercial oil well in 1914. Since that time production has been obtained in the following fields:

Name of Field	Type of Production
DeSoto-Red River-Bull Bayou	Oil and gas
Pleasant Hill	Oil and gas
Holly	Oil and gas
Benson	Oil and gas
Logansport	Gas and distillate
Sutherlin	Gas
Spider	Gas
Grogan	Oil

From 1914 to 1923, DeSoto and Red River Parishes were two of the leading oil and gas producing parishes in the state. According to the Louisiana Department of Conservation figures, DeSoto Parish ranked 29th among the oil producing parishes of Louisiana in 1939, 13th among the natural gas producing parishes. Red River Parish ranked 27th in total oil production, 21st in natural gas production.

The location, geology, and development of each field is discussed in the following pages. Production figures, compiled from back numbers of petroleum journals and files of the Louisiana Geological Survey, are listed under the most important fields. Production figures for 1929-1930, compiled from pipe line run reports, are listed in the accompanying tables.

TABLE I

Statement of Oil Produced by Fields

DeSoto Parish, Louisiana

Year	Benson Barrels	DeSoto-Red River-Bull Bayou Barrels	Grand Cane Barrels	Holly Barrels
1929	2,441.13	298,055.64	-	-
1930	1,301.36	315,294.83	-	241,365.38
1931	1,358.46	199,183.11	865.75	177,147.82
1932	840.42	137,822.05	845.00	88,375.78
1933	552.43	116,446.52	1,434.00	65,804.71
1934	-	144,596.09	1,350.00	63,688.07
1935	-	148,332.65	1,490.00	54,445.52
1936	-	149,470.02	740.00	49,817.50
1937	-	135,843.16	-	42,954.94
1938	-	142,828.52	-	30,369.16
1939 - First 3/4	-	82,550.59	-	22,450.05
Totals	6,493.80	1,870,423.18	6,724.75	836,418.93

TABLE I - Continued

Year	Pleasant Hill Barrels	Grogan Barrels	Total Barrels
1929	2,343.97	-	302,840.74
1930	2,437.69	-	560,399.26
1931	1,847.87	-	380,403.01
1932	1,441.75	-	229,325.00
1933	1,241.49	-	185,479.15
1934	1,047.93	-	210,682.09
1935	1,097.40	-	205,365.57
1936	1,476.53	-	201,504.05
1937	1,362.48	15,361.03	195,521.61
1938	1,459.88	9,192.50	183,850.06
1939 - First 3/4	663.35	4,117.62	109,781.61
Totals	16,420.34	28,671.15	2,765,152.15

TABLE II

Statement of Gas Produced by Fields

DeSoto Parish, Louisiana

Year	Benson M.C.F.	DeSoto-Red River-Bull Bayou M.C.F.	Holly M.C.F.	Pleasant Hill M.C.F.
1929	51,102	1,976,815	830,774	-
1930	56,157	1,526,898	303,827	-
1931	-	1,403,949	37,341	-
1932	-	1,268,276	39,400	-
1933	-	1,167,011	38,980	-
1934	-	1,202,614	37,726	-
1935	-	1,135,297	36,048	34,451
1936	-	1,217,763	26,046	55,074
1937	-	1,175,729	24,591	91,934
1938	-	1,226,119	16,993	64,505
1939 - First 3/4	-	848,918	11,320	44,941
Totals	107,259	14,149,389	1,403,046	290,905

TABLE II - Continued

Year	Sutherlin M.C.F.	Spider M.C.F.	Grogan M.C.F.	Total M.C.F.
1929	-	147,345	-	3,006,036
1930	-	111,143	-	1,998,025
1931	-	-	-	1,441,290
1932	-	-	-	1,307,676
1933	-	4,002	-	1,209,993
1934	-	20,082	-	1,260,422
1935	117,941	-	-	1,323,737
1936	103,245	28,780	-	1,430,908
1937	-	29,751	1,350	1,323,355
1938	-	-	3,240	1,310,857
1939 - First 3/4	-	-	500	905,679
Totals	221,186	341,103	5,090	16,517,978

TABLE III

Statement of Oil Produced by Fields

Red River Parish, Louisiana

Year	DeSoto-Red River-Bull Bayou Barrels	Crichton Barrels	Total Barrels
1929	732,898.80	147,583.39	880,482.19
1930	635,828.33	127,452.00	763,280.33
1931	555,680.28	129,205.30	684,885.58
1932	471,776.93	106,586.23	578,363.16
1933	367,112.92	98,177.74	465,290.66
1934	306,302.50	91,915.59	398,218.09
1935	288,097.94	82,862.97	370,960.91
1936	299,431.64	77,080.24	376,511.88
1937	206,181.91	77,641.47	283,823.38
1938	255,182.79	80,883.85	336,066.64
1939 - First 3/4	154,983.98	72,343.15	227,327.13
Totals	4,273,478.02	1,091,731.93	5,365,209.95

TABLE IV

Statement of Gas Produced by Fields

Red River Parish, Louisiana

Year	Crichton M.C.F.	DeSoto-Red River-Bull Bayou M.C.F.	Total M.C.F.
1929	7,560	521,248	528,808
1930	7,560	665,298	672,858
1931	9,810	561,183	570,993
1932	9,810	525,335	535,145
1933	9,810	455,530	465,340
1934	9,810	349,794	359,604
1935	9,810	311,350	321,160
1936	9,810	318,351	328,161
1937	9,910	247,841	257,750
1938	9,967	151,222	161,189
1939 - First 3/4	7,679	99,615	107,294
Totals	101,536	4,206,767	4,308,303

Logansport Gas Field

The Logansport structure is located in Township 11 North, Ranges 15 and 16 West, and Township 12 North, Ranges 15 and 16 West, in the western part of DeSoto Parish, Louisiana, in northeastern Shelby County and southwestern Panola County, Texas. Logansport, Louisiana, lies north of the center of the field; Joaquin, Texas, is about two miles west of the center of the field.

The development of the Logansport field opens a new gas producing area for this portion of northwestern Louisiana and tremendously increases the gas reserves of DeSoto Parish. A small amount of Upper Cretaceous oil production in the field area was obtained from broken chalks in the Ozan-Annona-Marlbrook sequence. In addition, small quantities of oil have been obtained from near the Upper Cretaceous-Lower Cretaceous contact. Gas production has been obtained from porous limes in the Sligo and Rodessa formations of the Trinity group.

The Logansport structure is an asymmetrical anticline. The contour maps (Plates VII, IX) show that the structure on the base of the Ozan chalk (Upper Cretaceous) and the base of the Ferry Lake formation (Lower Cretaceous) are similar. However, the field is not yet completely drilled, and any contour map is subject to revision.

The Logansport structure is revealed on the surface by: (1) the presence of an inlier of the Dolet Hills sand member (lower Logansport formation) completely surrounded by lignitic shales of the Cow Bayou member, which dip away from the center of the structure; (2) an upwarping of the Montgomery terrace surface over the structure (see p. 39) (3) the narrow, straight course of the Sabine River as it crosses the structure (see p. 22).

Interest in the Logansport area first began in 1916 with the discovery of oil in small quantities at a depth of 2,670 feet in a wildcat well drilled by the Citizen's Oil and Gas Company on the Bland lease in section 11, Township 11 North, Range 16 West. Several other tests were drilled during this and the following year, all of which proved unsuccessful.

Drilling activity was revived in 1922 with the completion of the DeSoto Oil and Gas Company's Payne No. 1 well in section 12, Township 11 North, Range 16 West, with an initial production of 10 barrels of oil per day from 2,660 feet.

H. A. Stebbinger, _et al._, completed their Pickering Lumber Company No. 1, C. Henry Survey, Shelby County, Texas, near the town of Joaquin on the west flank of the Logansport structure in 1936. Production in this area consists of gas and distillate. In May, 1937, Stebbinger, _et al._, completed the second gas-distillate well in this area, the Pickering Lumber Company No. 2 well, A. Hanson Survey, with an initial production of 2 to 10 million cubic feet of gas and approximately 150 barrels of distillate per day from 5,033-5,037 feet. A third gas well was completed by the Portex Oil and Gas Co. (successor of Stebbinger, _et al._) in 1937 from a depth of 5,100-5,200 feet. Neal and McDaniel completed a 30 million cubic foot gas and distillate well, the C. W. McDaniel No. 1, Willian Snyder Survey, at a depth of 5,010-5,080 feet in the "Glen Rose" (Lower Cretaceous) in July, 1939.

Production was extended to the north flank of the field by the completion of the Hunter Company Parker No. 1 well in June, 1938, section 26, Township 12 North, Range 16 West, two miles northeast of Logansport. This well had an initial open-flow potential of 4.25 million cubic feet of gas from a depth of 4,953-5,029 feet.

Recent drilling near the crest of the anticline in Shelby County, Texas, resulted in the completion of the Union Producing Company, M. E. Garrett No. A-1 well in August, 1940. This well, completed in the Rodessa formation of the Lower Cretaceous, extended commercial gas production a mile north and east of the former production in the Joaquin area. The Union Producing Company and the Southern Producing Company extended commercial production to the Louisiana side of the Sabine River in the latter part of 1940. The Southern Producing Company's Gannon-Frost well No. 1 in section 12, Township 11 North, Range 16 West, DeSoto Parish, had an initial production of 177 million cubic feet; and is believed to be the largest gas well completed in Louisiana.

Gas production in the Logansport field is at present from the Rodessa and Silgo formations of the Lower Cretaceous (Comanche).

Pleasant Hill Oil and Gas Field

The Pleasant Hill oil field is located in Township 10 North, Range 12 West, DeSoto Parish, and Townships 9 and 10 North, Range 12 West, Sabine Parish. If the Pelican area of DeSoto Parish is included within the field, its limits can be extended northward into Township 11 North, Range 12 West, DeSoto Parish. Exclusive of the Pelican area, approximately three-fourths of the field is in Sabine Parish, one-fourth in DeSoto Parish.

The Pleasant Hill field produces from a structural terrace on the south flank of the DeSoto-Red River-Bull Bayou uplift. Details of faults in the subsurface are not known.

The structure of the field is reflected on the surface as an inlier of the lignitic shales of the Cow Bayou member in the middle of the outcrop area of the Lime Hill member. The sediments are dominantly thin-bedded, mildly calcareous silts and clays with variable amounts of clay, limonite, and lignitic materials surrounding chocolate-brown, lignitic shales of the Cow Bayou member. Numerous small surface faults have been observed in the Sabine Parish portion of the field, but their relationship to the structure has not been worked out.

Production in the Pleasant Hill field is from the Paluxy formation (Lower Cretaceous). The first oil in the field was discovered in 1914, thirteen years before the field came into prominence, by the Standard Oil Company in their Ives well No.1, in section 34, Township 10 North, Range 12 West. In 1928, the well was still flowing and up to that time had produced about 35,000 barrels of oil, or an average of seven or eight barrels a day for the fourteen-year period. At the time of Matson's and Hopkins' paper (1917) on the DeSoto-Red River field, about sixteen wells had been drilled in the Pelican district, Townships 10 and 11 North, Range 12 West. About one-half of these were productive, the producing wells being scattered over an area extending from a point two miles northwest of Pelican southward for a distance of approximately seven miles. Only small amounts of oil were produced.

The area received very little attention between 1918 and 1927, when the Arkansas Fuel Oil Company brought in its Logan No. 1 well in section 33, Township 10 North, Range 12 West, at a depth of 3,209 feet. This well had an initial production of 513 barrels a day and rapidly declined to twenty barrels a day. One of the largest wells drilled in the field was the Magnolia Petroleum Company's Hall No. 2 well in section 33, Township 10 North, Range 12 West, with an initial flow of 1,300 barrels of oil.

The completion of several wells in the Benson area of DeSoto Parish, about five miles northwest of the Pleasant Hill field proper, in March, 1928, maintained interest in the area; and drilling continued.

The Plymouth Oil Company (Logan No. A-2 in section 23, Township 10 North, Range 13 West) and the Texas Company (Hamlin No. 1 in section 28, Township 10 North, Range 13 West) extended the limits of possible production several miles westward with gas shows of approximately 150,000 cubic feet of gas. The show in the Plymouth well was at 4,263 feet, that in the Texas well at 3,682 feet.

The field came back into prominence August 10, 1929, when the Bridges-Clark Oil Company's William's well No. 1, section 33, Township 10 North, Range 12 West, came in at 3,215 feet, flowing at a rate of 135 barrels an hour. Drilling activity, which had practically ceased a few months after the rediscovery in 1927, was revived after this completion. The following year was the second most active one in the field's history.

The possibility of production from the Nacatoch sand around the 2,400-foot level was indicated in January, 1930, when the Bridges-Clark Oil Company's Gay well No. 1, section 33, Township 10 North, Range 12 West, blew in at that depth making 15 million cubic feet of gas and salt water. In April of that year, the Bridges-Clark Oil Company again extended the field, this time a mile southeast, when they completed the R. L. Gay No. 1 well in section 3, Township 9 North, Range 12 West, as a 28 million cubic foot gasser at a total depth of 3,276 feet. This well initiated the first commercial gas production in the area.

From 1930 to the present time, drilling activity, production, and interest in the area has steadily declined. The production from the field is listed in the accompanying table. The production figures are incomplete, because they have been classified under the DeSoto-Red River-Bull

Bayou field several times.

Production Figures For Pleasant Hill Oil Field

(DeSoto and Sabine Parishes) (1)

Year	Oil 42-Gallon Barrels	Gas M.C.F.
1914		
1915	10,631 (1)	
1916	9,421 (1)	
1917	6,293 (1)	
1918	4,261 (1)	
1919		
1920		
1921		
1922		
1923	Figures not available	
1924		
1925		
1926		
1927	226,700	
1928	189,786	
1929	201,063	
1930	224,565	
1931	121,200 (2)	
1932	103,923	
1933	90,925	
1934	75,535	
1935	64,360	
1936	56,265	
1937	46,535	
1938	38,605	155
1939	31,788	185
1940		

(1) United States Bureau of Mines figures; all others from biennial reports of Louisiana Department of Conservation, 1936-37, 1937-38, 1938-39, and pipe line gauge reports. See statistical list of production (p.

(2) Figures for first ten months only.

Pleasant Hill Field

Summary of Data Concerning Crude Oil

(After Biennial Report, Louisiana Department of Conservation, 1938-39)

Properties of crude oil	
Gravity (degrees A. P. I.)	40.4
Color	brown-green
Sulphur, per cent	0.41
Viscosity at 100° F. sec.	37
Carbon residue, per cent	0.6
Total gasoline and naphtha	
Per cent	28.9
Degrees A. P. I.	54.7
Base of crude	P.-I.
Wax	present
Type structure	terrace, faulting
Approximate depth of producing sands	3,180-3,250 feet
Age of production	Paluxy
Discovery method	random drilling plus surface geology

Holly Oil and Gas Field

The Holly oil and gas field is located near the town of Holly in the north central portion of DeSoto Parish about seven miles north of Mansfield and includes areas in Townships 13 and 14 North, Ranges 13 and 14 West.

Structurally, the Holly area consists of an irregular dome centered in section 5, Township 13 North, Range 13 West, (see structure map, plate VII). No faults are known. The structure is indicated by the change in strike of the contact between the Cow Bayou and Lime Hill members (see geologic map, plate I). Also, the chocolate-brown and gray, lignitic, micaceous, and ferruginous clays and silts of the Cow Bayou member of the Logansport formation dip away from the center of the structure on all sides.

The first commercial gas well in the Holly field was completed by R. O. Roy on the Jessie Fuller lease in section 6, Township 13 North, Range 13 West, on August 5, 1928. The initial production on the well was estimated as 40 million cubic feet of gas, but later estimates placed it at 20 million cubic feet. This first well was followed by several failures and one producing well up to March, 1930, when Roy brought in his Farmer No. E-1 as a producing oil well. This well had an initial production of 336 barrels of 39.7 gravity oil in three and one-half hours from a total depth of 2,880 feet (Oil Weekly for March 21, 1930, says Woodbine sand). Production for the first twenty-four hours was 2,102 barrels through a three-quarters inch choke. Production later leveled off at about 1,300 barrels.

Following the completion of the Farmer No. E-1, Roy and others started an intensive drilling campaign in the area. The Standard Oil

Company of Louisiana purchased Roy's holdings in the field and continued the drilling campaign he had undertaken. In July, 1930, the Arkansas Fuel Oil Company's C. B. Scott well No. 2 came in as a small oil producer. The Standard Oil Company brought in its Dowling Brothers No. B-1, section 32, Township 14 North, Range 13 West, making 30 million cubic feet of gas and a spray of oil from 2,813 feet in December, 1930.

According to the Louisiana Department of Conservation, 240 productive acres of oil and gas land have been proved. Of the total acreage, 80 produce oil alone; 160 produce both gas and oil. Since drilling started, 43 wells have been drilled; 28 were dry holes; 10 are producers of oil; and 5 are producers of gas.

The production is from channel sands of Eagle Ford age. The approximate depths to the producing horizons are 2,540-2,580 feet and 2,820-2,900 feet.

Production figures compiled from pipe line run reports and tax reports are given in the statistical chart on production. Production figures compiled from the Oil and Gas Journal and the Biennial Reports of the Louisiana Department of Conservation are:

Year	Oil Barrels	Gas M.C.F. (1)
1930 and previous years	313,904	
1931	179,218	
1932	98,318	
1933	75,000	
1934	61,859	
1935	53,859	
1936	50,254	22
1937	42,976	20
1938	30,958	15
1939	29,118	13
Total	935,070	70

(1) Incomplete figures.

Holly Field

Summary of Data Concerning Crude Oil

(After Biennial Report, Louisiana Department of Conservation, 1938-39)

Properties of crude oil	
Gravity (degrees A. P. I.)	39.2
Coler	brown-green
Sulphur, per cent	0.57
Viscosity at 100° F. sec.	41
Carbon residue, per cent	1.2
Total gasoline and naphtha	
Per cent	33.2
Degrees A. P. I.	58.4
Base of crude	P.-I.
Wax present	
Residuum	
Per cent	20.7
Degrees A. P. I.	18.2
Carbon residue, per cent	5.8

Sutherlin Gas Field

The Sutherlin gas field is located in Township 12 North, Ranges 14 and 15 West, about seven miles south of Grand Cane.

The Sutherlin structure is an asymmetrical dome whose longer axis trends north-northeast (see structural map, plate VII). The anticline is incompletely drilled, and few details of the structure are known.

The greater portion of the field area is included in the Tertiary uplands province. The Midway (Cow Bayou member of Logansport formation) sediments exposed here consist predominantly of gray, chocolate-brown, and red, ferruginous clays and silts. The field is indicated on the surface by an inlier of the Dolet Hills sand surrounded by lignitic shales of the Cow Bayou member which dip away from the center of the structure.

One of the first known wells to be drilled in the area was the Higgins Oil and Fuel Company well in section 20, Township 12 North, Range 14 West. This well was drilled to a depth of 2,768 feet in 1909-1910 and was abandoned without commercial production. In 1913 and 1914, the Caddo Drilling Company drilled its Grand Cane Oil and Gas well No. 1 to a depth of 2,830 feet. The Texas-Standard Oil and Refining Company drilled its Sutherlin No. 1 to 2,842 feet in 1920 and obtained an initial production of 7.5 million cubic feet of gas from a depth of 2,782-2,819 feet. The T. A. Snell, Bradford No. 1 well, drilled to 2,991 feet, was completed in 1922. J. P. Evans drilled the Sutherlin No. 1 well, section 20, Township 12 North, Range 14 West, in 1926. This well, completed for 2 to 3 million cubic feet of gas and 25 barrels of oil, had shows of 2 to 5 barrels of oil at 2,850-2,852 feet and also encountered sands with 1 million cubic feet of gas at 2,896-2,900 feet and of 4 million cubic feet of gas at 2,903-04 feet. The Standard Oil Company and Pelican Natural Gas Company completed the Sutherlin No. 1 well for 11.75 million cubic feet of gas in 1932. An oil show at 2,823-2,826 feet and a 3 million cubic foot gas show at 2,779-2,783 feet were also reported.

The Hunter Company, 1935, completed its DeSoto Corporation Unit well No. 1 in section 29, Township 12 North, Range 14 West, for 16.75 million cubic feet of gas.

Since this time no known activity has occurred in the area. Production figures available on this field are given in the following chart.

Production in Sutherlin and Spider Areas

	Oil	Gas
Year	Barrels	M.C.F.
1940		
1939		
1938		0
1937		0
1936		103
1935		
1934		
1933		
1932		11.70 M.C.F. well section 19, Township 11 North, Range 14 West.

Spider Gas Field

The Spider gas field is located in southwestern DeSoto Parish in Township 11 North, Ranges 13 and 14 West.

The Spider area consists of two slightly asymmetrical anticlines whose longer axes trend north-northeast (see structural map, pl. VII). The area is incompletely drilled and few structural details are known.

The greater part of the field area consists of hills carved from the Dolet Hills and Cow Bayou members of the Logansport formation. The structure is indicated on the surface by the presence of an inlier of the Dolet Hills sand surrounded by lignitic shales of the Cow Bayou member, which dip away from the center of the structure.

Wells were drilled in this area as early as 1907, but production of commercial quantities was first obtained in 1914 when Benedum-Trees Oil Company completed a 2.5 million cubic foot gas well in section 11, Township 11 North, Range 14 West. Commercial quantities of gas have been obtained in several wells since that time. The J. Heidelburg Company completed a 1.5 million cubic foot gas well in section 11, Township 11 North, Range 11 West, in 1922. Benedum-Trees completed a 12 million cubic foot gas well at a depth of approximately 2,800 feet in section 7, Township 11 North, Range 13 West, in 1930. Later, this production changed to salt water; the hole was deepened to 3,054 feet, and was brought in at that depth as a 3 million cubic foot gas well.

The Century Oil and Drilling Company completed its Norton No. 1 well in section 27, Township 11 North, Range 14 West, in 1935. Initial production of this well was estimated at 5 to 10 million cubic feet of gas. The same year, H. Bailey, Incorporated, (E. L. Foster) brought in Youngblood No. 1 in section 9, Township 11 North, Range 14 West, with an estimated initial production of 4 to 6 million cubic feet of gas with salt water.

Production figures for the field from 1930-1939 are given in the statistical chart on parish production.

Benson Oil and Gas Field

The Benson oil and gas field is located near the town of Benson in the north central portion of Township 10 North, Range 13 West, and the south central portion of Township 11 North, Range 13 West.

The Benson structure is an anticline with its apex in section 3, Township 10 North, Range 13 West. Though closure on the upper Cretaceous formations is only approximately 50 feet, this has been great enough to focus attention on the possibilities of deeper production. Prospects for production in the Rodessa formation are very favorable. Sands in the Hosston formation may also yield production. Tertiary sediments cropping out over the structure belong to the Cow Bayou and Dolet Hills members of the Logansport formation (Midway group). The Dolet Hills member appears on the surface as an inlier of sand completely surrounded by the lignitic clay shales of the Cow Bayou member. The lignitic sediments dip outward in all directions from the center of the structure.

The first known wells in this area were drilled in sections 3 and 4, Township 10 North, Range 13 West, by L. G. Huntley and were completed as gas wells in 1920. In 1927, the William Sebastian Syndicate drilled a well in section 11, Township 10 North, Range 13 West, which developed a small amount of 45° Baumé gravity oil. The following year, the Benson Oil and Gas Company completed its Wolf No. 1 well in section 3, Township 10 North, Range 13 West, for a reported initial production of 80 barrels of 41° A.P.I. gravity oil, and its Wolf No. 2 well in the same section for a reported production of 12 million cubic feet of gas with a gasoline content of 334 gallons per million cubic feet of gas from 2,963 feet. In April, 1929, L. M. Moffitt completed the Boatwright No. 1 well in section 3, Township 10 North, Range 13 West, with an initial production of 2.75 million cubic feet of gas and a light spray of oil.

Production in the field area has been from sands near the Lower Cretaceous-Upper Cretaceous contact. Production figures for this field are listed in the statistical chart showing production in DeSoto Parish for the years 1929-1939.

Grogan Area

The Grogan area (also known as Wallace, Rambin, or Ramsey area) is located in the southeastern corner of Township 11 North, Range 11 West, in DeSoto Parish near the village of Wallace.

The structure of the Grogan area at present is incompletely defined by drilling; but, it appears to be a small, elongate dome on the southeast flank of the Chemard Lake structural terrace. The upper Midway sediments that crop out in the field area consist of lignitic silts and shales of the Cow Bayou member (Logansport formation). Dips up to fifteen or twenty degrees in these sediments on the flanks of the structure constitute the only known surface indications of its presence.

The Pullman Oil Company secured the first production at Grogan with the completion of its Ramsey No. A-1 well in the SW¼, SE¼, SE¼, NW¼, section 36, Township 11 North, Range 11 West, in June 1932, with an initial production of approximately 325 barrels a day from 2,961 feet.

The production in this well comes from the Paluxy of Lower Cretaceous age (Oil Weekly, June 28, 1937, p. 117). Several low, dry holes separate the field from the DeSoto-Red River-Bull Bayou field to the north.

A period of active drilling followed in this area. Paul Miller's Barron No. 1 well logged a saturated zone around 2,950 feet as did the Pullman Oil Company's Ramsey No. 3 well in the SE¼, NE¼, NW¼, section 36, Township 11 North, Range 11 West, which had a small amount of production from 2,946 feet.

There is no commercial production at present.

The oil obtained here was 32 gravity. Production figures for the field compiled from pipe line run and tax reports are presented in the statistical chart of production.

DeSoto-Red River-Bull Bayou Oil and Gas Field

The DeSoto-Red River-Bull Bayou oil and gas field is located in Township 11 North, Ranges 11 and 12 West, Township 12 North, Ranges 10, 11, and 12 West, and Township 13 North, Ranges 10, 11, and 12 West. It occupies areas in both DeSoto and Red River Parishes and consists of numerous scattered producing areas.

The DeSoto-Red River-Bull Bayou uplift is reflected on the surface as a topographic low. Hills averaging three hundred to three hundred and fifty feet in elevation, but in some places rising to over 400 feet, rim this low area on all sides.

The DeSoto-Red River-Bull Bayou field marks the highest structural portion of the Sabine Uplift from a regional point of view. It brings to the surface the oldest Midway sediments exposed in Louisiana (except locally around salt domes where Cretaceous strata crop out). These sediments belong to the Naborton formation and consist of slightly calcareous, dominantly buff, fine-grained sands, silts, and clays. Rimming the outcrop area of the Naborton formation on all sides and dipping away from the structure in all directions are the strata of the Logansport formation of Midway age. These beds consist of a basal sand (Dolet Hills) member, a middle lignitic shale (Cow Bayou) member, and an upper calcareous silt and clay (Lime Hill) member (see geologic maps, plates I, II, IV, and discussion on stratigraphy, pp. (94-155).

The field consists of an irregular dome slightly elongated in a northwest-southeast direction (see plate VIII). Two major fault zones with maximum displacements of about two hundred feet on the base of the Ozan chalk traverse the field in a northeast-southwest direction. Smaller radial faults and faults parallel to the two major zones of faulting further complicate the structure. Numerous small structures dot the surface of the domal uplift. These smaller structures and the faults localize the oil and gas accumulation in the field.

The major producing sands of the field are Lower Cretaceous (Paluxy) in age. The main producing zones in the field are:

Formation	Production	Depth (Top)
Nacatoch	gas	725-975'
"Chalk rock"	oil	850-1,050'
Paluxy	oil and gas	2,450-2,750'
"Glen Rose"	gas	---

The Fredericksburg limes, which are entirely absent over the center of the field, flank it on the north, west, and south. It is probable that the Fredericksburg sediments at one time extended completely across the DeSoto-Red River-Bull Bayou uplift, but post-Comanche and pre-Gulf erosion removed these sediments. The Eagle Ford shales were deposited on the unconformable lower Cretaceous erosion surface; and, after final uplift of the dome, oil and gas accumulated in the sands of the Paluxy against the overlying Eagle Ford shales.

In 1912, gas was discovered in the Nacatoch sand near Naborton in DeSoto Parish. This initial production in the DeSoto-Red River-Bull Bayou field was from a depth of eight hundred feet. A deeper drilling program was started in an attempt to locate productive sands below the Nacatoch formation. The Gulf Refining Company completed the Jenkins well No. 2 near Naborton in May, 1913, from a depth of about 2,400 feet; and the field rapidly became one of the most productive areas in the United States.

The Abington district of the field in Red River Parish became productive in 1914 with the completion of the Gulf Refining Company's Marston well No. 1 (NW$\frac{1}{4}$, SE$\frac{1}{4}$, section 14, Township 13 North, Range 11 West).

The first well was completed in the Crichton district on the east side of the Red River later in 1914 (Matson and Hopkins, 1917). On January 27, 1915, Kenn and Wolfe completed their Weiss well No. 1 in section 18, Township 13 North, Range 10 West, with an initial production of 6,500 barrels. The Crichton district was the center of activity of the field during 1915 (251 wells completed); and, with the discovery of the Gusher Bend pool in the fall of the same year, Crichton became the most important producing area of its time in the United States. At the same time, drilling and production in the Naborton area declined about fifty per cent from 1914. The Crichton district, in the southwestern part of Township 13 North, Range 10 West, and in the adjacent part of

Township 13 North, Range 11 West, was actively drilled the first two months of 1916. By March, the area had been pretty thoroughly defined and subsequent activity was slight. In September, a wildcat test in section 35, Township 13 North, Range 11 West, came in with an initial production of about 2,000 barrels and revived interest in the area southwest of Crichton.

The Producer's Oil Company completed a 3,500 barrel well on the Sander's lease, section 34, Township 13 North, Range 12 West, about two miles north of the town of Naborton in February, 1916. Subsequently, in May, while casing was being pulled, an abandoned gas well in section 25, Township 13 North, Range 12 West, blew in as a 2,000 barrel oil well and revived interest in the Naborton area. Late in 1916 and in 1917 the center of activity was in the Grand Bayou area in Township 13 North, Range 11 West, where efforts were made to prove the Naborton and Crichton districts were connected. This activity was centered on the property of the Grand Bayou Plantation Company in section 25, Township 13 North, Range 12 West, and on the Williams' lease in sections 29, 31, and 32, Township 13 North, Range 12 West.

The Texas Company completed a 1,000 barrel well in 1918 to open production in the Dolet Lake district. The discovery well in the Bull Bayou district, Bull Bayou Oil Company's Armistead well No. 1, section 23, Township 12 North, Range 11 West, was completed in December, 1918, with an initial production of 250 barrels. The field was extended for six miles south of Gusher Bend by drilling by 1919. These extensions included all the area between Bayou Pierre River and the Red River.

W. D. Strange Oil and Refining Company extended the field half a mile east of previous production with the completion of their Nelson well in section 8, Township 12 North, Range 10 West, in July, 1919, with an initial production of 12 million cubic feet of gas and 400 barrels of oil. J. M. Easthem, et al., completed their Harp well No. 1 at the same time to extend production southward. The Gulf Refining Company extended production to section 5, Township 12 North, Range 10 West, with the completion of their Gray Hook No. 1 in September, 1919, which came in flowing 2,500 barrels of oil from a depth of 2,725 feet. Initial production on this well was later set as 1,800 barrels (Oil Weekly, October 18, 1919). December witnessed the extension of the field into section 32, Township 13 North, Range 10 West, with the completion of a 5,000 barrel well on the Robinson lease by the Continental Asphalt and Petroleum Company. The successful completion of this well in an area which had been condemned during the days of the Gusher Bend and Crichton rushes stretched the known limits of production one-half mile to the north and east.

Early in January, 1920, the Texas Company completed its Roberts-Brown Lumber Company well No. 1 in section 4, Township 11 North, Range 12 West, and extended production nearly five miles to the southwest, thereby stimulating interest in southern DeSoto and northern Sabine Parishes.

R. E. Allison, et al., proved production in section 31, Township 13 North, Range 10 West, with the completion of their Nelson well No. 1. Extension of the producing area into section 27, Township 12 North, Range 11 West, occurred about this same time when Clark and Greer's Giauque well No. 1 blew in making 8 million cubic feet of gas and a spray of oil. The Continental Asphalt and Petroleum Company carried production one-quarter of a mile east into section 32, Township 13 North, Range 10 West, by the completion of their Robinson well No. B-4, with an initial yield of 1,000 barrels.

An important southward extension of the field occurred in late April, 1920, when Allison and Dingee completed their Albritton well No. 1

in section 35, Township 12 North, Range 11 West, with an initial yield of 2.5 million cubic feet of gas and 100 barrels of oil. Located not far from the first hole drilled in the field (a dry hole drilled by the Gulf Refining Company in 1912) and only three hundred feet from a dry hole drilled by the Fortuna Oil Company, this well extended the field two miles into condemned territory.

The last week of May, 1920, witnessed the highest daily production ever recorded in the field for a seven day average. The daily average production for this period was 23,855 barrels.

In July, 1920, the Palmer Trust Company extended production one mile southwest with the completion of its Jenkins well No. 1, section 21, Township 12 North, Range 11 West, with an initial production of 800 barrels of oil at 2,545 feet. An additional southward extension of this same area occurred in November, 1920, when the Amerada Petroleum Company completed its King No. 1 well in section 26, Township 12 North, Range 11 West, for 600 barrels at 2,610 feet.

February, 1921, witnessed the next notable extension of the field when the Boone Oil Company's Giauque No. 1 well in section 7, Township 11 North, Range 11 West, came in from 2,780 feet flowing 250 barrels. The flow later increased to 2,000 barrels a day, then declined to 400 barrels per day. This was the largest oil well completed in the field in some time, and it extended production about six miles southwest of the previous limits of the Bull Bayou field proper. An extension of the gas area of the field occurred in October, 1921, when the United States Drilling Corporation completed its Fletcher No. 2 well in section 2, Township 12 North, Range 10 West, for an initial yield of 15 million cubic feet of gas from 2,830 feet.

August, 1922, witnessed the development of a semi-wildcat area when the Fortuna Oil Company completed its Giauque well in section 33, Township 12 North, Range 11 West, for an initial oil production of 150 barrels per day and a large quantity of gas. In the later months of 1922, Tarver et al., opened the Dolet Hills area in DeSoto Parish by completing two wells in section 33, Township 12 North, Range 11 West, with an initial production of 500 and 800 barrels.

Interest in the area southeast of Mansfield and in the Dolet Hills was revived in October, 1923, when the Texas Pacific Coal and Oil Company's Roscoe wildcat well in section 22, Township 12 North, Range 13 West, blew in with an initial production of 10 million cubic feet of dry gas from 2,784 feet.

Drilling activity and interest in the field have gradually declined since 1923; and, although new tests have been started periodically, no important new areas have been developed. Benedum-Trees drew attention in December, 1928, to the area north of the old Naborton field when their State No. 1 well in section 22, Township 14 North, Range 12 West, came in making 25 million cubic feet of gas and approximately 100 barrels of salt water from 2,633 feet.

In October, 1930, E. C. Lucas reopened the area between the old Naborton field and the Bull Bayou field proper with completion of his Louisiana Delta Pecan No. 1, section 24, Township 13 North, Range 11 West, in Red River Parish as a 90 barrel pumper at 2,476 feet.

The year 1934 witnessed the opening of a new producing horizon in the old Naborton area of the DeSoto-Red River-Bull Bayou field. Bailey Gaunce, et al., completed their Jenkins No. 1 as a 6 million cubic foot gasser from a depth of 2,577-2,585 feet in the Lower Cretaceous.

The Windsor Oil and Gas Company and the Circle-W Oil Company completed four wells in Township 11 North, Range 11 West, in the Naborton area in 1935. These wells came in producing from 50 to 120 barrels a day after being acidized in the chalk (Oil Weekly, February 25, 1935, p. 70) and initiated the first commercial oil production from the "Chalk Series" in the field.

In 1937, Petroleum Heat and Power Company extended the field slightly with the completion of its Kavanaugh No. 1 well located in section 7, Township 11 North, Range 11 West, on the extreme southwest side of the field. Completed on December 30, at a total depth of 2,841 feet, the well came in making 105 barrels daily of 43 gravity oil through a one-quarter inch choke at 2,841 feet.

Sporadic drilling with little success characterized the years 1938, 1939, and 1940.

Production figures for the field since its inception are listed in the accompanying table. The figures have been compiled from the sources indicated; the division into parish production is approximate only.

General Production Figures For

DeSoto-Red River-Bull Bayou Oil and Gas Field (9)

	Gas M.C.F.		Oil 42-gallon barrels	
Year	DeSoto Parish (1)	Red River Parish (1)	DeSoto Parish (2)	Red River Parish (2)
1912				
1913				
1914			3,834,593 (5)	401,622
1915	10,000,000 (3)	(4)	1,797,175	6,802,349
1916			1,657,216	4,691,323
1917			1,370,889	1,664,955
1918	6,369,139	979,711	1,065,847	1,045,263
1919	4,345,799	1,541,567	1,200,000 (6)	2,900,000 (6)
1920	3,700,048	1,368,335	(8)	5,923,000
1921	2,123,945	355,152	719,000	2,844,000
1922	1,367,004	117,573	531,000	1,778,000
1923	1,246,262	788,542	429,000	1,207,000
1924	1,361,568	366,738	353,000	1,231,000
1925	1,683,830	321,473	305,000	1,074,000
1926	1,779,221	321,298	321,000	1,037,000
1927	1,819,814	362,540	541,000	1,070,000
1928	2,310,500	434,396	463,000	1,109,000
1929	2,784,249	473,787	276,000	987,000
1930	1,478,441	1,047,131	247,000	838,000
1931	1,059,357	778,678	192,000	713,000
1932	903,165	766,985	469,000	257,000
1933	822,614	2,248,652	411,000	190,000
1934	857,664	610,264	398,000	145,000
1935	714,327	552,319	379,000	143,000
1936	(7)	1,323,610 (7)	(7)	501,460 (7)
1937	(7)	1,135,423 (7)	(7)	537,365 (7)
1938	(7)	1,319,000 (7)	(7)	499,000 (7)
1939	(7)	1,708,035 (7)	(7)	402,719 (7)
1940				

(1) Figures compiled by Louisiana Department of Conservation (taken from Biennial Reports of Louisiana Department of Conservation for the years 1936-37 and 1938-39).

(2) Figures for 1914-35 from United States Bureau of Mines (given to thousands of barrels only for years 1919-1935 inclusive). Figures for 1936-1938 from A. I. M. E. reports for production for those years. Separation of production into that produced from each parish approximate only.

(3) Estimated cubic feet of gas produced during the years 1912-1917 inclusive for the entire field.

(4) Production for Red River Parish included in the DeSoto figures.

(5) Includes figures for Sabine Parish.

(6) Estimated.

(7) Gas and oil production figures for the DeSoto Parish portion of the field included under Red River Parish.

(8) Figures for the DeSoto Parish portion of the field included under figures for Red River Parish.

(9) See statistical list of production.

In summary, pertinent data on the field is tabulated below (after Biennial Report, Louisiana Department of Conservation, for 1938-39 and United States Bureau of Mines):

Date of discovery: gas, 1912; oil, 1913.

Location: DeSoto and Red River Parishes, Louisiana.

Type of structure: Irregular dome, faulted.

Area proved: 11,000 acres, oil
3,300 acres, gas
14,300 acres, total

Total wells completed to end of 1939: 1,781.

Producing wells abandoned in 1939: 51.

Gravity in degrees Baumé: 38.1-45.6

Oil production methods at end of 1939:

Flowing	24
Pumping	131
Gas injection into reservoir	12

Number of oil and gas wells, end of 1939:

Oil	131
Gas	24
Total	155

Physical properties and percentage analysis of DeSoto-Red River crude as determined by the United States Bureau of Mines are:

Properties:

Formational source ....Paluxy

Depth ....2,350-2,800 feet

Color ....Brown-green

Gravity ....specific 0.822
A. P. I. 40.6

Viscosity ....at 70 degrees F. (21 degrees C) 40
at 100 degrees F. (38 degrees C) 37

Sulphur per cent .... .16-.45

Carbon residue per cent 6

Total gasoline and naptha ...... per cent 24.7
A. P. I. 54.4

Analysis: %

Gasoline	27.6
Kerosene, etc.	36.1
Gas, oil, etc.	10.8
Lubricating oil	13.1
Total distillates	87.6
Sulphur	0.21
Residuum, etc.	12.4
Total	100.21
Base of crude	Paraffin.

Potential Producing Zones In DeSoto And Red River Parishes

Jurassic System

The Smackover, Buckner, and Cotton Valley formations offer good potentialities for deep production in this area. Insufficient evidence is available, however, to indicate their exact character and prospects in DeSoto and Red River Parishes.

Cretaceous System

Comanche Series

The Hosston formation, on the basis of known information, offers few possibilities for commercial oil and gas production. Commercial gas production has been obtained from the Sligo and Rodessa formations in western DeSoto Parish and in eastern Shelby County, Texas. Should this porosity exist in areas farther east, the Sligo, Rodessa, and Pine Island formations are excellent potential producing zones in the Sutherlin, Spider, Benson, Holly, and DeSoto-Red River-Bull Bayou fields and other areas. The Mooringsport and Paluxy formations are also good potential producing zones in these same areas. The Paluxy, in particular, is a possible producing horizon in these parishes wherever the structure is favorable.

The Ferry Lake formation and the Fredericksburg sediments are not likely to produce commercial oil or gas in DeSoto or Red River Parishes.

Gulf Series

The sediments of the Gulf Series have been penetrated by numerous borings in this area and their lithologic character is fairly well known. Sands in the Eagle Ford, Brownstown-Tokio, and Nacatoch formations are latent zones for small quantities of oil and gas. The Buckrange sand and the Ector, Ozan, Annona, and Saratoga chalks are potential producing zones in DeSoto and Red River Parishes.

Tertiary System

Paleocene Series

The subsurface Paleocene sediments of these parishes offer no possibilities of commercial production since they are predominantly shaly, limy, and compact in character.

APPENDIX I

Soil Groups Recognized in DeSoto and Red River Parishes and Adjacent Areas

Soils as normally considered today are products of the environmental conditions under which they have developed or are developing; they are the summation products resulting from the action and effect of topography, physiography, climate, and biology on geologic sediments. In this respect soils are unquestionably one of the most valuable geologic resources known to man.

With the soil profile as the fundamental unit of classification, pedologic technicians have, within the last few years, thoroughly revised and expanded former soils classifications. In so far as known, all the soils of the DeSoto-Red River Parish area belong to the Red and Yellow Soil Groups of Pedalfers. The writer has prepared, with the invaluable assistance of D. L. Fontenot, field technician of the Soil Conservation Service, upper west Red River District, Louisiana, a list of the important soils types occurring in DeSoto and Red River Parishes and adjacent areas. These soils, with brief discussions of their characteristics are listed below.

The abbreviations employed are:

f.s.l. .... fine sandy loam

v.f.s.l. .... very fine sandy loam

l.f.s. .... loamy fine sand

f.s. .... fine sand

Group 1. Well Drained Upland Soils.

Orangeburg f.s.l.
Luverne v.f.s.l.
Atwood f.s.l.
Kirvin pebbly v.f.s.l.
Ruston v.f.s.l.
Ruston f.s.l.

The soils of this group are well developed with red, rather open, generally productive subsoils. Erosion is often severe, a direct result of the early clearing and tilling of these soils. The slopes on which they occur are undulating to hilly, and, except on hilltops, rarely fall below a three per cent slope.

Group 2. Moderately Permeable Upland Soils (Yellow Subsoils).

Bowie v.f.s.l.
Bowie f.s.l.
Sawyer v.f.s.l.
Sawyer f.s.l.
Sawyer v.f.s.l. (shallow phase)

These soils occur on gentle to undulating slopes, but are also common at the base of steep slopes. The surface material is grayish-yellow in color and consists of fine or very fine, sandy loam. The subsoil consists of rather friable, yellow, sandy clay. Sawyer has a heavy, usually compact, lower B horizon while Bowie is friable throughout, with occasionally a slightly compacted or loosely cemented lower B horizon.

Erosion is normally light in this group of soils, but due to their usual position on hillsides, they are frequently gullied. The amount of erosion is frequently difficult to determine as a result of the blending of surface and subsoil.

Group 3. Heavy, Slowly Permeable Upland Soils

Shubuta pebbly v.f.s.l.
Shubuta v.f.s.l.
Shubuta f.s.l.
Boswell v.f.s.l.
Cuthbert pebbly v.f.s.l.

This group possesses grayish-yellow friable surface soils and red, compact, often plastic clay to silty clay subsoils. Boswell is compact throughout and is derived from heavy clays; the remaining soils of this group are derived from alternating clay and sandy clay beds. These slowly permeable soils, occupying undulating to hilly topography, are subject to severe sheet and gully erosion unless protected in some fashion.

Group 4. Heavy, Slowly Permeable, Poorly Developed Upland Soils – Generally Forest Soils.

Cuthbert v.f.s.l.
Susquehanna, Boswell, Kirvin Complex
Guin soils, undifferentiated
Susquehanna v.f.s.l.
Susquehanna f.s.l.
Susquehanna clay
Boswell clay

The members of this group are quite variable in color, texture, and parent material, yet they possess many characteristics in common. They all have heavy, slowly permeable subsoils, are all usually poorly developed, are very acid, and are almost entirely non-agricultural. At the present time they must be classed in large part as forest or "cut-over" lands. All the members of the group are subject to heavy erosion.

Group 5. Well Drained Coastal Plain Terraces (1)

Cahaba v.f.s.l.
Cahaba f.s.l.
Kalmia v.f.s.l.
Kalmia f.s.l.
Isagora v.f.s.l.

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(1) The Coastal Plain terraces of the Soil Conservation Service Technicians of this area refer to terraces whose underlying materials were derived from Coastal Plain sediments, in contrast to the sediments of the Red River terraces which were derived from the Permian Basin of north Texas. The contrast between the two in appearance and characteristics is great.

These soils are developed on stream terraces from old alluvium of coastal plain origin. They have yellow to grayish-yellow friable surfaces, occupy the better drained portions of the terraces, and except on escarpments and drains occur on gently undulating topography. Cahaba and Kalmia have respectively reddish-brown and yellow, friable, sandy clay subsoils. Isagora differs in having a heavier, more compact, lower B horizon and usually a mottled upper B horizon. Erosion, except on steep slopes, is normally not severe and can easily be controlled.

Group 6. Poorly Drained Coastal Plain Terrace Soils.

Leaf v.f.s.l. (deep phase)
Leaf v.f.s.l.
Myatt silt loam
Myatt v.f.s.l.
Myatt fine sand

The main difference between this and Group 5 is one of drainage and development. The topography of these soils is almost level, and depressed spots, which remain submerged throughout the wet seasons, are frequent.

Drainage in the Leaf series is further retarded by heavy, plastic clays in the lower subsoil, and in the Myatt by a very compact silt to silty clay hardpan layer. These areas are known locally as "post oak flats". The typical vegetation of these soils is slow growing hardwoods with occasional pines. In the depressed areas, water oaks, haws, and other low shrubs predominate. The high water table, heavy forest growth, and underbrush make these soils unfavorable for tillage.

Group 7. Moderately Permeable Red River Terrace Soils.

Stidham v.f.s.l.
Muskegee v.f.s.l.

The soils of this group are considered to be the Red River equivalents of the upland soils of Group 2, but, in general, with finer textured surfaces and less undulating topography. They occur in discontinuous strips bordering the Red River and in many sections have been mixed with Coastal Plain materials.

Due to the almost level topography, erosion is usually a minor problem. Muskegee, like Sawyer (Group 2), has poor surface and internal drainage as a result of the heavy clay subsoils that occur from fourteen to forty inches beneath the surface. Stidham is similar to Bowie or Kalmia and has better surface and internal drainage than Muskegee.

Group 8. Heavy, Well Drained Red River Terrace Soils.

Dogherty v.f.s.l.
Teller v.f.s.l.
Teller f.s.l.
Morse v.f.s.l.

This group of soils is similar in topography and in color and texture of profile to those of Group 3. They differ essentially in that Group 8 is derived from old Red River alluvium which, in a fresh state, occurs generally from ten to twenty-five feet below the surface. The Morse v.f.s.l. carries calcareous material within approximately three feet of the surface. The Dogherty differs from the other soils in having a red, well oxidized, friable subsoil resembling the Ruston. It is normally closely associated with the Teller.

Erosion is severe on most unprotected, cultivated areas. The soils characteristically occur on the escarpments and adjacent drainage interslope areas dissected from the nearly flat terrace surface. Slopes are fairly steep; as a rule they vary from six to twenty per cent. Erosion of all types, but particularly gullying, has removed much of the soil from cultivated areas.

Group 9. Heavy Red River Terrace Soils Derived From Slightly Weathered Alluvium.

Morse clay, dark surface phase
Morse clay
Morse clay loam

The Morse series resembles Red River bottom soils in color and texture on slopes of from two to eight per cent. Examination of both types brings to light considerable differences, however, especially in color and profile development. The surface is reddish-brown to brownish-gray clay or clay loam, is plastic, and is very sticky when wet, very hard when dry. The upper portion is usually mottled with gray, red, and brown from a few inches to a few feet beneath the surface. Frequently lime nodules occur on the surface; the soil itself is highly calcareous near the surface. The largest portion of the series consists of clay; the clay loam is largely a mixture of over-washed materials. Erosion of these soils is, as a rule, quite severe.

Group 10. Poorly Drained Red River Terrace Soils.

Muskegee silt loam
Teller, Muskegee, Wrightsville Complex
Muskegee, Wrightsville Complex

These soils occupy low to gently undulating surfaces with many depressed, poorly drained areas. The surface consists of fine, sandy loam or silt loam of a gray to grayish-yellow color. The subsoil varies in color but is usually gray, mottled with yellow and brown, sandy clay or clay. The group is associated with and very similar to Group 15.

Erosion is generally not very serious due to the flatness of the topography. Very little of the area covered by these soils is tillable and most of it is now in forests or pastures. Typically the vegetation consists of a mixture of hardwood and pine.

Group 11. Well Drained Alluvial Soils Derived From Coastal Plain Material.

Ochlockonee silt loam
Ochlockonee v.f.s.l.
Iuka silt loam
Iuka v.f.s.l.
Hannahatchie v.f.s.l.

These are well drained sandy or silt loams subject to occasional overflow. The topography is level to gently sloping, the higher and better drained series usually occur near the present or near old stream channels. Ochlockonee is typical of natural levees in this area. The soils of this group are probably the most productive soils of the area. The silt loams near levee crests are normally considered best as they may be cultivated much longer than the sandy types.

Group 12. Poorly Drained Alluvial Soils Derived From Coastal Plain Material.

Alluvial soils, undifferentiated
Bibb silt loam
Riverwash

These soils are similar to those of Group 11 in normally having mixed or undifferentiated profiles. Only the Bibb departs in this characteristic. They differ from the soils of Group 11 in being poorly drained.

Bibb is characterized by a gray, poorly developed profile. Riverwash consists, as the name implies, of wash material from recent overflows of the river. As a general rule this is largely fine sand or silt. The undifferentiated alluvium is usually restricted to bottoms of small tributary streams or drains and is badly mixed with recent wash material.

Group 13. Red River Alluvial Soils.

Miller v.f.s.l.
Yahola v.f.s.l.
Miller silty clay
Yahola silty clay

Portland v.f.s.l.
Miller clay
Yahola clay
Portland silty clay
Portland clay
Buxin clay
Perry silty clay
Perry clay, overwashed clay.

The soils of this group are all red or brown of some shade. The Miller soils are purplish-red with heavy subsoils. They, like the other soils of the group, are calcareous. The Yahola soils differ from the Miller in having a lighter subsoil. The fine sandy loams and silt loams of these series are characteristic of natural levees, the clays of the back swamp. The Portland, Buxin, and Perry soils are less rich in lime than the Miller and Yahola soils and generally occupy backswamp areas. They possess, where typically developed, bluish-gray subsoils.

Group 14. Imperfectly Drained Mound Phase Series - Terrace and Uplands.

Kalmia v.f.s.l., mound phase
Stidham v.f.s.l., mound phase
Isagora v.f.s.l., mound phase
Bowie v.f.s.l., mound phase
Segno v.f.s.l., mound phase
Sawyer v.f.s.l., mound phase
Muskegee v.f.s.l., mound phase
Teller v.f.s.l., mound phase

This group of agricultural mound phase soils is of both upland and terrace origin. They possess essentially equal slope, topography, and position. Those of the upland series are almost level to gently sloping, are undissected, occupy a bench-like position, or occur at the base of steep slopes. Those of the terrace series are similar to the soils of Group 5, but differ in being less well drained and in the presence of mounds. These soils possess yellow to light yellowish-gray surfaces with mottled red and gray, yellow subsoils. Erosion is not normally very heavy in these soils.

Group 15. Poorly Drained Mound Phase Series - Terrace and Uplands.

Susquehanna v.f.s.l., mound phase
Caddo v.f.s.l., mound phase
Leaf v.f.s.l., mound phase
Wrightsville silt loam, mound phase

These soils are characteristically poorly drained with gray surface and gray mottled subsoils. The topography is level to gently sloping with insufficient surface and internal drainage. The Leaf and Susquehanna have compact, heavy-mottled, gray and red subsoils, while the Caddo has a mottled, gray silt to silty clay subsoil, usually cemented by a powdery, silty material. The greater portion of these soils supports woods or forests; crop yields on the cultivated areas are poor. The vegetation is characteristically hardwood mixed with pine.

Group 16. Sands and Loamy Fine Sands.

Guin f.s.l. (predominantly light textured)
Ruston l.f.s.
Norfolk l.f.s.
Kalmia f.s.
Ruston f.s.
Norfolk f.s.

This group of highly variable, individual soils stands as a similar and distinct group when contrasted with other soil groups. The surface consists of loose, friable, yellow to gray, fine sand from twenty inches to many feet in depth. The Guin, particularly, is highly variable in depth of the surface layer. The subsoils range from loose, unconsolidated, sandy loam to fine sandy clay that is friable throughout.

Erosion and creep of these soils are highly advanced. In unprotected areas, movement by wind is known to occur.

APPENDIX II

List of the more important upper Midway microfossil localities of DeSoto and Red River Parishes and adjacent areas. The numbers refer to corresponding numbers on the regional map (Plate IV). The most important localities are marked with an asterisk.

Microfaunal Localities

Map No.

1. GM. Loc. 80. Road cuts along local road on east side of Castor Bayou flood plain in the NW¼ of section 19, Township 12 North, Range 15 West, DeSoto Parish, Louisiana. Cow Bayou member.

2. GM. Loc. 69. Thirty-foot water well in the NE¼ of SW¼ of section 31, Township 11 North, Range 14 West, DeSoto Parish, Louisiana. Sample from depth of twenty feet. Elevation at top of hole, 240 feet (Paulin altimeter). Cow Bayou member.

*3. GM. Loc. 118. Road cut, 3.7 miles southeast of Hunter on south side of Hunter-Converse road in SW¼ of section 9, Township 10 North, Range 15 West, DeSoto Parish, Louisiana. Elevation, 260 feet (Paulin altimeter). Type locality of Cow Bayou member.

4. GM. Loc. 198. Fifteen-foot augur-hole on hillside on south side of Hunter-Converse Highway, 0.1 mile north of DeSoto-Sabine Parish line in section 16, Township 10 North, Range 14 West, DeSoto Parish, Louisiana. Elevation, top of hole, 225 feet (Paulin altimeter). Depth of samples, 9 and 13-13½ feet. Lime Hill member.

5. GM. Loc. 150. Road cuts and ravines along Louisiana Highway 749, 5.1 miles south of Mansfield, in center of the NW¼ of section 3, Township 11 North, Range 13 West, DeSoto Parish, Louisiana. Foraminifera from chocolate-brown, silty clays. Top elevation, 330 feet (Paulin altimeter). Cow Bayou member.

6. GM. Loc. 335. Sixteen-foot augur-hole in the SE corner SW¼, SW¼, NW¼ of section 11, Township 11 North, Range 13 West, DeSoto Parish, Louisiana. Elevation at top of hole, 305 feet (Paulin altimeter). Foraminifera from khaki, silty clays at depth of 10-12 feet. Cow Bayou member.

7. GM. Loc. 169. Road cut on north side of Oxford-Benson road near center of E$\frac{1}{2}$ of section 26, Township 11 North, Range 13 West, DeSoto Parish, Louisiana. Elevation, 270-275 feet (Paulin altimeter). Lime Hill member.

8. GM. Loc. 343. Fifteen-foot augur-hole alongside local road one-quarter mile east of Catuna. Hole near middle of North line of section 33, Township 11 North, Range 13 West, DeSoto Parish, Louisiana. Elevation at top of hole, 298 feet (Paulin altimeter). Samples from 6-7 feet contained arenaceous foraminifera. Cow Bayou member.

9. GM. Loc. 164. Road cut on west side of U. S. Highway 171 about 0.7 miles south of Catuna in SW$\frac{1}{4}$ of section 33, Township 11 North, Range 13 West, DeSoto Parish, Louisiana. Cow Bayou member.

10. GM. Loc. 126. Road cuts and ravines on south side of Louisiana Highway 745, three miles west of Benson near center of line between sections 7 and 18, Township 10 North, Range 13 West, DeSoto Parish, Louisiana. Top elevation, 300 feet (Paulin altimeter). Cow Bayou member.

*11. GM. Loc. 124. Road cut about one-half mile west of U. S. Highway 171 on the north side of Louisiana Highway 745 in the SW$\frac{1}{4}$ of NE$\frac{1}{4}$ of section 9, Township 10 North, Range 13 West, DeSoto Parish, Louisiana. Fossils collected from chocolate-brown clays. Elevation, 240 feet (Paulin altimeter). Benson facies of the Cow Bayou member.

12. GM. Loc. 193. Ravines in the SE$\frac{1}{4}$, NE$\frac{1}{4}$, section 7, Township 10 North, Range 12 West, along local road extending south from Louisiana Highway 419, DeSoto Parish, Louisiana. Top elevation, 280 feet (Paulin altimeter). Foraminifera from chocolate-brown shales. Lime Hill member.

13. GM. Loc. 146. Road cut on Louisiana Highway 419, 4.55 miles east of Benson in the SE$\frac{1}{4}$ of section 5, Township 10 North, Range 12 West, DeSoto Parish, Louisiana. Top elevation, 315 feet (Paulin altimeter). Lime Hill member.

14. GM. Loc. 175. Road cut on west side of local road from Pelican to Pleasant Hill in the NE$\frac{1}{4}$, NW$\frac{1}{4}$, section 15, Township 10 North, Range 12 West, DeSoto Parish, Louisiana. Elevation, 330 feet (Paulin altimeter). Lime Hill member.

15. GM. Loc. 176. Fifteen-foot augur-hole on east side of local road in SW corner of section 1, Township 10 North, Range 12 West, DeSoto Parish, Louisiana. Elevation, top of hole, 360 feet (Paulin altimeter). Depth of sample, 8 feet. Lime Hill member.

*16. GM. Loc. 163. Road cut on west side of Louisiana Highway 180 on Lime Hill about two and one-half miles northeast of Pleasant Hill in the SW$\frac{1}{4}$, SW$\frac{1}{4}$ of section 23, Township 10

North, Range 11 West, Sabine Parish, Louisiana. Foraminifera occur in gray, calcareous clays. Elevation, top, 323 feet (Paulin altimeter). Type locality, Lime Hill member.

19. GM. Loc. 192. Small ravine about twenty-five yards east of local road, approximately in the center of the $W\frac{1}{2}$, $NE\frac{1}{4}$ of section 1, Township 10 North, Range 11 West, DeSoto Parish, Louisiana. Top elevation, 205 feet (Paulin altimeter). Cow Bayou member.

*22. GM. Loc. 258. Road cut in the $NE\frac{1}{4}$, $SE\frac{1}{4}$ of section 33, Township 10 North, Range 10 West, Natchitoches Parish, Louisiana, along dirt road leading west from Louisiana Highway 404. Foraminifera collected from yellowish-brown sandy silts overlain by calcareous siltstone concretions. Sediments crop out on road just east of bridge over Rock's Creek. Elevation, 170 feet on bridge (Paulin altimeter). Lime Hill member.

24. GM. Loc. 220. Exposures in small ravine near local road in $NE\frac{1}{4}$, $NW\frac{1}{4}$ of section 32, Township 13 North, Range 9 West, Red River Parish, Louisiana. Foraminifera from gray silty clays beneath Prairie (Pleistocene) formation. Contact of Tertiary and Pleistocene, 157 feet (Paulin altimeter).

List of the most important upper Midway molluscan localities of DeSoto Parish and adjacent areas. The numbers refer to corresponding numbers on the regional map.

Map No.

11. GM. Loc. 124. Road cut about one-half mile west of U. S. Highway 171 on north side of Louisiana Highway 745 in the $SW\frac{1}{4}$, $NE\frac{1}{4}$ of section 9, Township 10 North, Range 13 West, DeSoto Parish, Louisiana. Fossils collected from chocolate-brown clays. Elevation, 240 feet (Paulin altimeter). Type locality of Benson facies of Cow Bayou member.

16. RJL. Loc. 7. Yellowish-brown, sandy silts and calcareous siltstone concretions exposed on the south side of U. S. Highway 171 in central part of section 33, Township 9 North, Range 13 West, Sabine Parish, Louisiana, approximately two miles northwest of Noble and one-half mile south of bridge over Bayou San Patricio. Elevation, 205 feet (Paulin altimeter).

17. RJL. Loc. 1. Exposures in the approximate center of $NW\frac{1}{4}$ of section 1, Township 9 North, Range 12 West, Sabine Parish, Louisiana, close to one-third mile east of the "Old Ferrell" place where Harris (1899) reported fossils. Elevation, 270 feet (Paulin altimeter). Fossils occur in large, calcareous, septarian concretions.

18. GM. Loc. 163 (RJL. Loc. 2). Road cut on west side of Louisiana Highway 180 on Lime Hill about two and one-half miles northwest of Pleasant Hill in the SW$\frac{1}{4}$, SW$\frac{1}{4}$ of section 23, Township 10 North, Range 11 West, Sabine Parish, Louisiana. Fossils in large, calcareous, siltstone concretions. Top elevation, 323 feet (Paulin altimeter). Type locality, Lime Hill member.

20. GM. Loc. 302 (RJL. Loc. 4). Yellow-brown, calcareous, septarian and siltstone concretions occurring on hill top on north side of Louisiana Highway 180 in SW$\frac{1}{4}$, NE$\frac{1}{4}$ of section 13, Township 10 North, Range 11 West, DeSoto Parish, Louisiana. Elevation, 280 feet (Paulin altimeter).

21. GM. Loc. 301 (RJL. Loc. 3). Calcareous, septarian and siltstone concretions on hillside in SW corner of section 24, Township 10 North, Range 11 West, Sabine Parish, Louisiana, on south side of Hollis Creek on Walker's Place. Elevation, 310 feet (Paulin altimeter).

22. GM. Loc. 258 (RJL. Loc. 9). Road cuts in NE$\frac{1}{4}$, SE$\frac{1}{4}$ of section 33, Township 10 North, Range 10 West, Natchitoches Parish, Louisiana, along dirt road leading west from Louisiana Highway 404. Fossils in yellowish-brown, sandy silts overlain by calcareous, siltstone concretions. Sediments crop out on road just east of bridge over Rock's Creek. Elevation, 170 feet on bridge (Paulin altimeter). Lime Hill member.

23. RJL. Loc. 5. Yellow-brown, calcareous, septarian concretions in gray, calcareous clays occurring one hundred and fifty yards east of Louisiana Highway 404 approximately four and one-half miles south of Ajax on road to Marthaville. Locality in NE$\frac{1}{4}$, NW$\frac{1}{4}$, section 34, Township 10 North, Range 10 West, Natchitoches Parish, Louisiana, south side of Williamson Branch.

25. Road cut along Louisiana Highway 1 in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, of section 4, Township 9 North, Range 11 West, Sabine Parish, Louisiana. Only a few specimens found in ferruginous concretionary layer underlain by grayish-brown, silty clay. Elevation, 370 feet (Paulin altimeter).

SELECTED BIBLIOGRAPHY

Adams, G. I. (1901) Oil and gas fields of the upper Cretaceous and Tertiary formations of the western Gulf Coast, U. S. Geol. Survey, Bull. 184, pp. 31-62.

Adkins, W. S. (1918) The Weno and Paw Paw formations of the Texas Comanchean, Univ. Texas, Bull. 1856, pp. 1-172.

____________ (1928) Handbook of Texas Cretaceous fossils, Univ. Texas, Bull. 2838.

____________ (1930) Texas Comanchean echinoids of the genus Macraster, Univ. Texas, Bull. 3001, pp. 100-120.

____________ (1932) The Mesozoic systems in Texas, in The geology of Texas, vol. 1, Pt. 2, Univ. Texas, Bull. 3232, pp. 239-518.

____________ (1935) Upper Cretaceous unconformities in Texas, Univ. Texas, Bull. 3501, pp. 141-149.

Adkins, W. S. and Winton, W. M. (1919) Paleontological correlation of the Fredericksburg and Washita formations in north Texas, Univ. Texas, Bull. 1945, 128 pages.

Albritton, Claude C., Jr. (1937) Upper Jurassic and lower Cretaceous foraminifera from the Malone Mountains, Trans Pecos, Texas, Jour. Paleont., vol. 11, no. 1, pp. 19-23.

Albritton, Claude C., Jr. and Phleger, F. B., Jr. (1937) Foraminiferal zonation of certain upper Cretaceous clays of Texas, Jour. Paleont., vol. 11, no. 4, pp. 347-354.

Aldrich, T. H. (1886) Alabama Geol. Survey, Bull. 1, p. 12.

____________ (1895) New or little known Tertiary mollusca from Alabama and Texas, Bull. Am. Paleont., vol. 1, no. 2, pp. 53-82.

Alexander, C. I. (1925) Micrology of the upper Fredericksburg and lower Washita formations, Univ. Texas, Bull. 2544, pp. 65-67.

____________ (1927) The stratigraphic range of the Cretaceous ostracod Bairdia subdeltoidea and its allies, Jour. Paleont., vol. 1, pp. 29-33.

____________ (1928) The time range of the foraminiferan, Flabellammina alexanderi in the lower Cretaceous of north Texas, Jour. Paleont., vol. 2, no. 1, pp. 43-44.

____________ (1929) Ostracoda of the Cretaceous of north Texas, Univ. Texas, Bull. 2907, pp. 1-137.

——————— (1932) New names for two species of ostracoda from the Cretaceous, Jour. Paleont., vol. 6, no. 1, p. 101.

——————— (1933) Shell structure of the ostracode genus Cytheropteron, and species from the Cretaceous of Texas, Jour. Paleont., vol. 7, pp. 181-214.

——————— (1934A) Ostracoda of the genera Monoceratina and Orthonotacythere from the Cretaceous of Texas, Jour. Paleont., vol. 8, no. 1, pp. 57-67.

——————— (1934B) Ostracoda of the Midway (Eocene) of Texas, Jour. Paleont., vol. 8, no. 2, pp. 206-237.

——————— (1935A) Stratigraphy of the Midway group (Eocene) of southwest Arkansas and northwest Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 19, no. 5, pp. 696-699.

——————— (1935B) Ostracoda of the genus Argilloecia from the Cretaceous of Texas, Jour. Paleont., vol. 9, no. 4, pp. 356-357.

——————— (1936) Ostracoda of the genera Eucythere, Cytherura, Eucytherura, and Loxoconcha from the Cretaceous of Texas, Jour. Paleont., vol. 10, no. 8, pp. 689-694.

——————— (1939) Common and significant species of foraminifera and ostracoda of the Brownstown, Ozan, and Annona formations, of southwestern Arkansas, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 64.

Alexander, C. I. and Smith, J. P. (1932) Foraminifera of the genera Flabellammina and Frankeina from the Cretaceous of Texas, Jour. Paleont., vol. 6, no. 4, pp. 299-311.

Antevs, Ernst (1929) Quaternary marine terraces in non-glaciated regions and changes of level of sea and land, Am. Jour. Sci., 5th ser., vol. 17.

Bailey, T. L. (1923) Geology and natural resources of Colorado County, Univ. Texas, Bull. 2333.

Barnes, G. W. (1879) The hillocks or mound formations of San Diego, California, Am. Naturalist, vol. 13, pp. 565-571.

Barrell, Joseph (1908) Relation between climate and terrestrial deposits, Jour. Geol., vol. 16, Pt. 1, pp. 159-190; Pt. 2, pp. 255-295; Pt. 3, pp. 363-384.

——————— (1917) Rhythms and measurements of geologic time, Geol. Soc. Am., Bull., vol. 28, pp. 745-904.

Barrett, W. M. (1930) Magnotometer study of the Caddo-Shreveport uplift, Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 14, no. 2.

Barry, J. O. (1942) (See LeBlanc, R. J.)

Barton, D. C. (1925) American salt-dome problems in the light of Roumanian and German salt domes, Am. Assoc. Petrol Geol., Bull., vol. 9, no. 9, pp. 1227-1268.

——— (1926) Geology salt dome oil fields, Am. Assoc. Petrol. Geol., Tulsa, Okla., pp. 167-208.

——— (1931) Effect of salt domes on accumulation of petroleum, Am. Assoc. Petrol. Geol., Bull., vol. 15, no. 1, pp. 61-66.

——— (1934) A discussion of the paper by L. S. Brown on age of the Gulf border salt deposits, Am. Assoc. Petrol. Geol., Bull., vol. 18, pp. 1286-1292.

——— (1936) Mechanics of formation of salt domes with special reference to Gulf Coast salt domes of Texas and Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 17, no. 9, pp. 1025-1083.

Barton, D. C., Ritz, C., and Hickey, Maude (1933) Gulf Coast geosyncline, Am. Assoc. Petrol. Geol., Bull., vol. 17, no. 12, pp. 1446-1458.

Bates, M. (1918) The oil and gas fields of northern Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 2, pp. 61-70.

——— (1920) A concrete example of the use of well logs (Red River-Crichton oil field, Louisiana), Am. Inst. Min. Metall. Eng., Trans., vol. 61, pp. 590-597.

Bayley, G. W. R. (1851) Red River raft and region, DeBow's New Orleans Monthly Rev., vol. 10, pp. 103-106.

Belisle, J. G. (1912) History of Sabine Parish, Louisiana, Sabine Banner Press, 319 pages.

Bell, H. W. (1926) Report of the Division of Minerals (1924-1926), La. Dept. Conserv., 7th Biennial Rept., pp. 19-44.

Berry, E. W. (1915) A study of the Tertiary floras of the Atlantic and Gulf Coastal Plain, Am. Ph. Soc., Pr. 50, pp. 301-315.

——— (1916A) Erosion intervals in the Eocene of the Mississippi embayment, U. S. Geol. Survey, Prof. Paper 95, pp. 73-82.

——— (1916B) The lower Eocene flora of southeastern North America, U. S. Geol. Survey, Prof. Paper 91, 481 pages.

——— (1923) Additions to the flora of the Wilcox group, U. S. Geol. Survey, Prof. Paper 131, pp. 1-20.

——— (1924) American Tertiary terrestrial plants and their interdigitation with marine deposits, Geol. Soc. Am., Bull., vol. 35, pp. 767-784.

——————— (1925) The upper Cretaceous ostracoda from Maryland, Am. Jour. Sci., 5th ser., vol. 9.

Bingham, D. H. (1937) Developments in Arkansas-Louisiana-Texas area, 1936-37, Am. Assoc. Petrol. Geol., Bull., vol. 21, no. 8, pp. 1068-1073.

Blanpied, B. W. (1938A) Structure and stratigraphy of the Hatchetigbee anticline and Jackson fault areas, Alabama, (abstract), Am. Assoc. Petrol. Geol., 23rd Ann. Meeting, Pr., pp. 36-37.

——————— (1938B) Age and correlation of the Salt Mountain limestone, Clarke County, Alabama, (abstract), Am. Assoc. Petrol. Geol., 23rd Ann. Meeting, Pr., p. 32.

——————— (1939A) Bibliography of publications related to the geology of the Arkansas-Louisiana-Texas area, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 179.

——————— (1939B) Tentative correlation charts of the Gulf Coast Mesozoic and Cenozoic systems, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 125.

Böse, Emil and Cavins, O. A. (1927) The Cretaceous and Tertiary of southern Texas and northern Mexico, Univ. Texas, Bull. 2748.

Bowles, Edgar (1939) Eocene and Paleocene Turritellidae of the Atlantic and Gulf Coastal Plain of North America, Jour. Paleont., vol. 13, pp. 267-336.

Bramlette, M. N. (1924A) Bentonite in the upper Cretaceous of Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 8, no. 3, pp. 342-344.

——————— (1924B) Volcanic rocks in the Cretaceous of Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 8, pp. 344-346.

Branner, G. C., et al. (1929) Geologic map of Arkansas, Ark. Geol. Survey.

Branner, J. C. (1897) The former extension of the Appalachians across Mississippi, Louisiana, and Texas, Am. Jour. Sci., 4th ser., vol. 4.

——————— (1905) Natural mounds or hog-wallows, Science, vol. 21, no. 535, pp. 514-516.

Brantley, J. E. (1920) Petroleum possibilities of Alabama, Ala. Geol. Survey, Bull. 22, Pt. 2, southern Alabama, 149 pages.

——————— (1924) Résumé of the geology of the Gulf Coastal Plain, Am. Assoc. Petrol. Geol., Bull., vol. 8, no. 1, pp. 21-28.

Brown, C. S. (1907) Lignites of Mississippi, Miss. Geol. Survey, Bull., no. 3.

Brown, Levi S. (1934) Age of Gulf Border salt deposits, Am. Assoc. Petrol. Geol., Bull., vol. 18, no. 10, pp. 1227-1296.

Bruner, E. O. (1904) Handbook of Louisiana, issued by the La. St. Board of Agr. and Immigration, Baton Rouge, 280 pages.

Bucher, W. H. (1933) The deformation of the earth's crust, Princeton, N. J., (Princeton Press), 518 pages.

Burchard, E. F. (1915) Iron-bearing deposits in Bossier, Caddo, and Webster Parishes, Louisiana, U. S. Geol. Survey, Bull. 620, pp. 129-150.

Burckhardt, Carlos (1930) Étude synthétique sur le Mesozoique mexicain, Soc. Paleont., Suisse, Mem., vols. 49-50, 280 pages.

Bushnell, D. I. Jr. (1905) The small mounds of the United States, Science, vol. 22, no. 570, pp. 712-714.

Calahan, L. W. (1939) Diagnostic fossils of the Arkansas-Louisiana-Texas area with fossil plates and explanations, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 36.

Campbell, M. R. (1906) Natural mounds, Jour. Geol., vol. 14, pp. 708-717.

Canu, F. and Bassler, R. S. (1924) American and European Tertiary bryozoa, Geol. Soc. Am., Bull., vol. 35, pp. 847-850.

Carsey, D. O. (1926) Foraminifera of the Cretaceous of central Texas, Univ. Texas, Bull. 2612, 56 pages.

Chamberlain, T. C. (1890) Some additional evidence bearing on the interval between the glacial epochs, Geol. Soc. Am., Bull., vol. 1, pp. 469-480.

Chawner, W. D. (1936) Geology of Catahoula and Concordia Parishes, La. Dept. Conserv., Bull. 9, 232 pages.

Cheney, C. A. (1922) Salt domes of northeastern Texas, Oil and Gas Jour., Jan. 6, pp. 82-83.

Chisholm, W. F. (1928) Report of the division of Minerals (1926-28), La. Dept. Conserv., 8th Biennial Rept., pp. 106-181.

Clapp, F. G. (1912) The occurrence of oil and gas deposits associated with quaquaversal structure, Econ. Geol., vol. 7, pp. 364-381.

——— (1913) Outline of the geology of natural gas in the United States, Econ. Geol., vol. 8, no. 6, pp. 517-542.

———(1917) Revision of the structural classification of petroleum and natural gas fields, Geol. Soc. Am., Bull., vol. 28, pp. 553-602.

——— (1929) Role of geologic structure in the accumulation of petroleum, in Structure of typical American oil fields, Am. Assoc. Petrol. Geol., vol. 2, Tulsa, Okla., pp. 667-716.

Clark, F. W. (1924) Data of geochemistry, U. S. Geol. Survey, Bull. 770.

Clark, W. B. and Martin, G. C. (1901) Eocene, Rept., Maryland Geol. Survey.

Clark, W. B. and Twitchell, M. W. (1915) The Mesozoic and Cenozoic echinodermata of the United States, U. S. Geol. Survey, Mon. 54, 341 pages.

Claypool, C. B. (1933) The Wilcox of central Texas, (abstract), Univ. of Illinois Press, 1933, and Ph. D. dissertation (unpublished), Univ. of Illinois.

Conrad, T. A. (1832-1835) Fossil shells of the Tertiary formations of North American, Philadelphia. Republished by G. R. Harris (Washington, 1893).

Cooke, C. W. (1924) American and European Eocene and Oligocene mollusks, Geol. Soc. Am., Bull., vol. 35, pp. 851-856.

———————— (1926) The Cenozoic formations, Ala. Geol. Survey, Spec. Rept. 14, pp. 251-297.

———————— (1934) Akerman formation in Alabama, Am. Assoc. Petrol. Geol., Bull., vol. 17, pp. 192-195.

Craft, B. C. (1933) Oil and gas development in north Louisiana, south Arkansas, and Mississippi in 1932, Am. Inst. Min. Metall. Eng., Trans., vol. 103, pp. 294-299.

———————— (1935) Oil and gas development in Louisiana in 1934, Am. Inst. Min. Metall. Eng., Trans., vol. 114, pp. 320-331.

———————— (1936) Oil and gas development in Louisiana in 1935, Am. Inst. Min. Metall. Eng., Trans., vol. 118, pp. 283-297.

Crider, A. F. (1906) Geology and mineral resources of Mississippi, U. S. Geol. Survey, Bull. 283.

———————— (1923) Relation of upper Cretaceous to Eocene structures in Louisiana and Arkansas (with discussion), Am. Assoc. Petrol. Geol., Bull., vol. 7, no. 4, pp. 379-383.

———————— (1924) Volcanic ash in northern Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 8, no. 4, pp. 524-525.

Crider, A. F. and Johnson, L. C. (1906) Summary of the underground water resources of Mississippi, U. S..Geol. Survey, W. S. Paper 159.

Cushman, J. A. (1925-1942) Cushman Lab. Foram. Res., Contrib.

———————— (1927) American Cretaceous foraminifera figured by

Ehrenberg, Jour. Paleont., vol. 1, no. 3, pp. 213-217.

——————— (1931A) A preliminary report on the foraminifera of Tennessee, Tenn. Div. Geol., Bull. 41.

——————— (1931B) The foraminifera of the Saratoga chalk, Jour. Paleont., vol. 5, no. 4, pp. 297-315.

——————— (1932) The foraminifera of the Annona chalk, Jour. Paleont., vol. 6, no. 4, pp. 330-345.

——————— (1933) Foraminifera: their classification and economic use, Spcial Publ. 4 and 5, Cushman Lab. Foram. Res., Contrib., Sharon, Mass.

——————— (1935) The upper Eocene foraminifera of the southeastern United States, U. S. Geol. Survey, Prof. Paper 181, 88 pages.

———————(1936A) Geology and paleontology of the Georges Bank canyons, Pt. 4, Cretaceous and late Tertiary foraminifera, Geol. Soc. Am., Bull., vol. 47, no. 3, pp. 413-440.

———————(1936B) New genera and species of the families Verneuilinidae and Valvulinidae and of the subfamily Virgulinae, Cushman Lab. Foram. Res., Contrib., Special Publ. 6, 71 pages.

———————(1940) Midway foraminifera from Alabama, Cushman Lab. Foram. Res., Contrib., vol. 16, pp. 51-73.

Cushman, J. A. and Garrett, J. B. (1939) Eocene foraminifera of Wilcox age from Woods Bluff, Alabama, Cushman Lab. Foram. Res., Contrib., vol. 15, Pt. 4, pp. 77-89.

Cushman, J. A. and Jarvis, R. W. (1932) Upper Cretaceous foraminifera from Trinidad, U. S. Nat. Mus., Pr., vol. 80, art. 14, pp. 1-60.

Daly, R. A. (1920) A recent world-wide sinking of ocean level, Geol. Mag., vol. 57, pp. 246-261.

——————— (1929) Swinging sea level of the ice age, Geol. Soc. Am., Bull., vol. 40, pp. 721-734.

Dane, Carl H. (1929) Upper Cretaceous formations of southwestern Arkansas, Ark. Geol. Survey, Bull. 1, pp. 79-90.

Dane, Carl H. and Stephenson, L. W. (1928) Notes on the Taylor and Navarro formations in east central Texas, Am. Assoc. Petrol. Geol., Bull., vol. 12, no. 1.

Darby, W. A. (1817) A geographical description of Louisiana, Philadelphia, Pa.

——————— (1818) The emigrants guide to the western and southwestern states and territories, etc., accompanied by a map of the United States, including Louisiana, New York.

Davies, A. Morley (1934) Tertiary faunas, vols. 1 and 2, Thomas Murby & Co., London, 252 pages.

Davis, W. M. (1887) The classification of lakes, Science, vol. 10, pp. 142-143.

———— (1930) Origin of limestone caverns, Geol. Soc. Am., Bull., vol. 41, pp. 475-628.

Dennett, Daniel (1876) Louisiana as it is, New Orleans, "Eureka" Press.

Dohm, C. F. (1936) List of maps dealing with Placquemines and St. Bernard Parishes, in Lower Mississippi River delta, La. Dept. Conserv., Geol. Bull. 8, pp. 321-338.

Dumble W of Tex 1920

Dumble, E. T. (1894) The Cenozoic deposits of Texas, Jour. Geol., vol. 2, pp. 549-567.

———— (1895) Cretaceous of western Texas and Coahuila, Mexico, Geol. Soc. Am., Bull. 6, pp. 375-388.

———— (1920) The geology of east Texas, Univ. Texas, Bull. 1869, 388 pages.

Dunbar, C. P. (1933) A list of some of the available publications dealing with the geology and mineral resources of Louisiana and related areas, La. Dept. Conserv., Bull. 22, Pt. 3, pp. 235-269.

Easton, H. D. (1927) Review of petroleum in Arkansas and Louisiana during 1926, in Petroleum development and technology in 1926, Am. Inst. Min. Metall. Eng., pp. 674-677.

Egger, J. G. (1907) Foraminiferen der Seewener Kreideschichten, Sitz. Bay. Akad., Wiss., Munchen, pp. 1-52.

Ehrenberg, C. G. (1854) Mikrogeologie, Das Wirken des unsichtbaren kleinen Lebens auf der Erde, 2 vols., Leipzig.

Ellisor, A. C. (1925) The age and correlation of the chalk at White Cliffs, Arkansas, with notes on the subsurface correlation of northeast Texas, Am. Assoc. Petrol. Geol., Bull., vol. 9, no. 8, pp. 1152-1164.

Ellisor, A. C. and Teagle, J. (1934) Correlation of Pecan Gap chalk in Texas, Am. Assoc. Petrol. Geol., Bull., vol. 18, pp. 1506-1536.

Farnsworth, P. J. (1906) On the origin of the small mounds of the lower Mississippi valley and Texas, Science, vol. 23, no. 589, pp. 583-584.

Featherman, A. (1872) Third annual report of the Botanical Survey of southwest and northwest Louisiana, La. St. Univ. Rept. for 1871, p. 107.

Fisk, H. N. (1938A) Geology of Grant and LaSalle Parishes, La. Dept. Conserv., Geol. Bull. 10, 246 pages.

__________ (1938B) Pleistocene exposures in the western Florida Parishes, Louisiana, La. Dept. Conserv., Geol. Bull. 12., pp. 3-25.

__________ (1939A) Igneous and metamorphic rocks from Pleistocene gravels of central Louisiana, Jour. Sedimentary Petrol., vol. 9, no. 1, pp. 20-27.

__________ (1939B) Depositional terrace slopes in Louisiana, Jour. of Geomorphology, vol. 2, no. 2, pp. 181-200.

__________ (1940) Geology of Avoyelles and Rapides Parishes, La. Dept. Conserv., Geol. Bull. 18, 239 pages.

__________ (1941) Midway-Wilcox deltaic mass, (abstract), Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 5, p. 941.

Ford, J. A. (1936) Analysis of Indian village site collections from Louisiana and Mississippi, La. Dept. Conserv., Anthropological Study 2.

Fortier, Alice (1914) Louisiana, vols. 1 and 2, Century Historical Assoc.

Franke, A. (1925) Die Foraminiferen der pommerschen Kreide, Abhandl. Geol. Paleont. Instit., Univ. Greifswald, vol. 6, pp. 1-96.

__________ (1928) Die Foraminiferen der Oberen Kreide Nord - und Mittel-deutschlands, Abhandl. Preuss. Geol. Landes, vol. 111, pp. 1-207.

Frink, J. W. (1941) Subsurface Pleistocene of Louisiana, La. Dept. Conserv., Geol. Bull. 19, pp. 369-429.

Galliher, E. W. (1935A) Glauconitic genesis, Geol. Soc. Am., Bull., vol. 46, no. 9, pp. 1351-1366.

__________ (1935B) Geology of glauconite, Am. Assoc. Petrol. Geol., Bull., vol. 19, pp. 1569-1601.

Galloway, J. J. (1932) Manual of foraminifera, Principa Press.

Galloway, J. J. and Morrey, Margaret (1931) Late Cretaceous foraminifera from Tabasco, Mexico, Jour. Paleont., vol. 5, no. 4, pp. 329-354.

Gardner, J. H. (1905) Physical origin of certain concretions, Jour. Geol., vol. 16.

Gardner, Julia A. (1923) New species of mollusca from the Eocene deposits of southwestern Texas, U. S. Geol. Survey, Prof. Paper 131 D, pp. 109-115.

__________ (1924) Fossiliferous marine Wilcox in Texas, Am. Jour. Sci., 5th ser., vol. 7, pp. 141-145.

——————— (1926A) The restoration of Ostrea multilirata Conrad, 1857, Wash. Acad. Sci. Jour., vol. 16, pp. 513-514.

——————— (1926B) On Scott's new correlation of the Texas Midway, Am. Jour. Sci., 5th ser., vol. 12, pp. 452-455.

——————— (1931) Relation of certain foreign faunas to Midway fauna of Texas, Am. Assoc. Petrol. Geol., Bull., vol. 15, no. 2, pp. 149-160.

——————— (1933) Kincaid formation, name proposed for lower Midway of Texas, Am. Assoc. Petrol. Geol., Bull., vol. 17, p. 744.

——————— (1941) Analysis of faunal studies of western Gulf province, Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 4, pp. 644-649.

Gardner, Julia A. and Bowles, Edgar (1939) The Venericardea planicosta group in the Gulf province, U. S. Geol. Survey, Prof. Paper 189 F, pp. 143-215.

George, W. O. and Bay, H. X. (1935) Subsurface data on Covington County, Mississippi, Am. Assoc. Petrol. Geol., Bull., vol. 19, pp. 1148-1161.

Giauque, Florien (1902) Map of DeSoto Parish, Louisiana, Cincinnati, Ohio.

Gilbert, G. K. (1899) Ripple marks and cross-bedding, Geol. Soc. Am., Bull., vol. 10, pp. 135-140.

Glenk, Robert (1921) Louisiana lignite, La. Dept. Conserv., Bull. 8, 65 pages.

Goldman, M. L. (1919) General characteristics, mode of occurrence, and origin of glauconite, Wash. Acad. Sci. Jour., vol. 9, pp. 501-502.

Gordon, C. H. (1909) Chalk formation of northeast Texas, Am. Jour. Sci., 4th ser., vol. 27, art. 29, pp. 369-374.

——————— (1911) Geology and underground waters of northeastern Texas, U. S. Geol. Survey, W. S. Paper 276.

Grabau, A. W. (1921) Textbook of geology, Pt. 2, Historical Geology, New York, 976 pages.

——————— (1924) Principles of stratigraphy, New York, N. Y.

Grim, R. E. (1928) Recent oil and gas prospecting in Mississippi with a brief study of subsurface geology, Miss. Geol. Survey, Bull. 21, 98 pages.

——————— (1936) The Eocene sediments of Mississippi, Miss Geol. Survey, Bull. 30, 240 pages.

Gueno, Albert (See Woodward, T. P.)

Haase, Fred M. (1932) Lower Peachtree area, Wilcox County, Alabama. Am. Assoc. Petrol. Geol., Bull., vol. 16, no. 5, pp. 492-493.

Hager, D. S. (1928) Factors affecting the color of sedimentary rocks, Am. Assoc. Petrol. Geol., Bull., vol. 12, pp. 911-917.

Hager, Lee (1904) The mounds of the southern oil fields, Eng. and Min. Jour., vol. 78, pp. 137-139.

Hammill, C. A. (1921) The Cretaceous of northwestern Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 5, no. 2, pp. 298-310.

Harris, G. D. (1892) The Tertiary geology of southern Arkansas, Ark. Geol. Survey, Ann. Rept., Pt. 2.

———— (1894A) On the geological position of the Eocene deposits of Maryland and Virginia, Am. Jour. Sci., 3rd ser., vol. 47, pp. 301-304.

———— (1894B) Tertiary geology of southern Arkansas, Ark. Geol. Survey, Ann. Rept. 2, 1892, 206 pages.

———— (1896) The Midway stage, Bull. Am. Paleont., vol. 1, no. 4, 156 pages.

———— (1897) The lignitic stage: Pt. 1, Stratigraphy and pelecypoda, Bull. Am. Paleont., vol. 2, no. 9, pp. 195-295.

———— (1899A) The Cretaceous and lower Eocene faunas of Louisiana, La. Geol. Survey, Spec. Rept., no. 6, pp. 289-310.

———— (1899B) The lignitic stage: Pt. 2, Scaphopoda, gastropoda, pteropoda, and cephalopoda, Bull. Am. Paleont., no. 11, 128 pages.

———— (1902A) The geology of the Mississippi embayment, La. St. Exp. Sta., Geol. Agr. La., Pt. 6, pp. 1-39.

———— (1902B) Oil in Louisiana, La. St. Exp. Sta., Geol. Agr. La., Pt. 6, Spec. Rept. 8, pp. 261-275.

———— (1907) Rock salt in Louisiana, La. Geol. Survey, Bull. 7.

———— (1908) The geological occurrence of rock salt in Louisiana and east Texas, Econ. Geol., vol. 4, pp. 12-34.

———— (1910A) Oil and gas in Louisiana, U. S. Geol. Survey, Bull. 429, 192 pages.

———— (1910B) The lower Tertiaries of Louisiana, Science, n. s., vol. 31, p. 502.

———— (1919) Pelecypoda of the St. Maurice and Claiborne stages, Bull. Am. Paleont., vol. 6, p. 6.

Harris, G. D. and Pachero, J. A. A. (1902) The subterranean waters of Louisiana, La. St. Exp. Sta., Spec. Rept. 6, Pt. 6, pp. 195-252.

Harris, G. D., Maurey, F. J., and Reinecke, L. (1908) Rock salt, its origin, geologic occurrence, and economic importance in the state of Louisiana, together with brief notes and references to all known salt deposits and industries in the world, La. Geol. Survey, Bull. 8, 259 pages.

Harris, G. D., Perrine, I., and Hopper, W. E. Oil and gas in northwestern Louisiana, La. St. Exp. Sta., La. Geol. Survey, Bull. 8, pp. 1-52.

Harris, G. D. and Veatch, A. C. (1899) A preliminary report on the geology of Louisiana, La. St. Exp. Sta., Geol. Agr. La., Pt. 5, 139 pages.

Harris, W. H. (1881) Louisiana, products, resources, and attraction, New Orleans, La.

Hazzard, Roy T. (1939A) Notes on the Comanche and pre-Comanche ? Mesozoic formations of the Arkansas-Louisiana-Texas area and a suggested correlation with northern Mexico, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 155.

——————— (1939B) The Centerpoint volcanics of southwest Arkansas; a facies of the Eagle Ford of northeast Texas, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 133.

Hazzard, Roy T. and Lloyd, A. M. (1939) Northeast-southwest cross section from Dallas County, Arkansas, to Rusk County, Texas, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 92.

Heilprin, Angelo (1884A) Contributions to the Tertiary geology and paleontology of the United States, Philadelphia, Pa.

——————— (1884B) The Tertiary geology of the eastern and southern United States, Acad. Nat. Sci. Philadelphia, Jour., vol. 9, p. 151.

Hilgard, E. W. (1860) Report on the geology and agriculture of the state of Mississippi, E. Barksdale, Jackson, Miss., 391 pages.

——————— (1866) On the Quaternary formations of the state of Mississippi, Am. Jour. Sci., vol. 91, pp. 311-325.

——————— (1867) On the Tertiary formations of Mississippi and Alabama, Am. Jour. Sci., 2nd ser., vol. 43, pp. 29-41.

——————— (1869A) Summary of results of a late geological reconnaissance of Louisiana, Am. Jour. Sci., 2nd ser., vol. 48, pp. 331-346.

——————— (1869B) Preliminary report of a geological reconnaissance of Louisiana, DeBow's Rev., vol. 37-38, pp. 754-769.

———— (1871) On the geological history of the Gulf of Mexico, Am. Jour. Sci., 3rd ser., vol. 2, pp. 391-404; La. St. Univ., Ann. Rept., pp. 207-222.

———— (1873) Supplementary and final report of a geological reconnaissance of the state of Louisiana, New Orleans, La. 44 pages.

———— (1905) The prairie mounds of Louisiana, Science, vol. 21, no. 536, pp. 551-552.

Hill, Robert T. (1887) The topography and geology of the Cross Timbers and surrounding regions in northern Texas, Am. Jour. Sci., 3rd ser., vol. 33, no. 196.

———— (1888) Neozoic geology of southwestern Arkansas, Ark. Geol. Survey, Ann. Rept. for 1888, vol. 2, pp. 1-260.

———— (1899-1900) Geography and geology of the Black and Grand prairies, Texas, U. S. Geol. Survey, 21st Ann. Rept., Pt. 7.

———— (1906) On the origin of the small mounds of the lower Mississippi valley and Texas, Science, vol. 23, no. 592, pp. 704-706.

———— (1921) Two limestone formations of the Cretaceous of Texas which transgress time diagonally, Science, n. s., vol. 53, pp. 190-191.

Hjulstrom, Filip (1934-35) Studies of the morphological activity of rivers as illustrated by the River Fyris, Bull. Geol. Inst., Univ. Upsala, vol. 25, no. 4, pp. 221-525.

Hobbs, W. H. (1907) Some topographic features formed at the time of earthquakes and the origin of mounds in the Gulf plain, Am. Jour. Sci., 4th ser., vol. 23, pp. 245-256.

Hollick, Arthur (1899) A report on a collection of fossil plants from northwestern Louisiana, La. St. Exp. Sta., La. Geol. Survey, Rept. 1899, pp. 276-289.

Hopkins, F. V. (1870) First annual report of the Louisiana state geological survey, La. St. Seminary of Learning, Rept. 1869, pp. 77-111.

———— (1871) Second annual report of the geological survey of Louisiana, La. St. Univ., Rept. 1870, 35 pages, New Orleans, La.

Howe, H. V. (1924A) The Arkadelphia formation, historical summary, La. St. Univ. Bull., n. s., vol. 16, no. 5, Pt. 1, 10 pages.

———— (1924B) The Arkadelphia formation, stratigraphy, La. St. Univ., Bull., n. s., vol. 16, no. 5, Pt. 2, 17 pages.

———— (1924C) The Nacatoch formation, La. St. Univ., Bull., n. s., vol. 16, no. 5, Pt. 3, 25 pages.

——————— (1925A) Extension of Midway formation into Louisiana, Pan-Am. Geol., vol. 43, no. 4, p. 309.

——————— (1925B) The Many salt dome, Sabine Parish, Louisiana, Am. Assoc. Petrol. Geol., vol. 9, no. 1, pp. 170-171.

——————— (1933) Review of Tertiary stratigraphy of Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 17, pp. 613-655; Gulf Coast oil fields, Am. Assoc. Petrol. Geol., Tulsa, Okla., pp. 383-423.

——————— (1936A) Louisiana petroleum stratigraphy, Oil and Gas Jour., vol. 34, no. 48, pp. 98-111, 124-128, Apr. 16; La. Dept. Conserv., Gen. Min. Bull. 27, pp. 1-46.

——————— (1936B) The foraminiferal genus Palmula Isaac Lea, 1833, Jour. Paleont., vol. 10, no. 5, pp. 415-416; (abstract), Geol. Soc. Am., Pr., 1935, p. 363.

Howe, H. V. and Garrett, J. B., Jr. (1934) Louisiana Sabine Eocene ostracoda, La. Dept. Conserv., Geol. Bull. 4, 64 pages.

Hull, J. P. D. (1923) Notes on the stratigraphy of producing sands in northern Louisiana and southern Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 7, no. 4, pp. 362-369.

——————— (1925) Guide notes on the Midway in southwestern Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 9, no. 1, pp. 167-170.

Hull, J. P. D. and Spooner, W. C. (1922) A review of oil and gas pools in north Louisiana territory, Am. Assoc. Petrol. Geol., Bull., vol. 6, no. 3, pp. 179-192.

Humphreys, A. A. and Abbot, H. L. (1861) Report upon the physics and hydraulics of the Mississippi River, U. S. Army, Corps of Topographical Engs., Prof. Paper 4, Philadelphia; reprinted with additions ......Prof. Paper 13, Washington, D. C. (1876).

Huner, John, Jr. (1939) Geology of Caldwell and Winn Parishes, La. Dept. Conserv., Geol. Bull. 15, 356 pages.

Huntley, L. G. (1923) The Sabine Uplift, Arkansas-Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 7, no. 2, pp. 179-181.

Hussey, Keith M. (See Murray, Grover, Jr.)

Imlay, R. W. (1936) Geology of the middle part of the Sierra de Parras, Geol. Soc. Am., Bull., vol. 47, pp. 1091-1152.

——————— (1937A) Geology of the middle part of the Sierra de Parras, Geol. Soc. Am., Bull., vol. 48, pp. 587-630.

——————— (1937B) Stratigraphy and paleontology of the upper Cretaceous beds along the eastern side of Laguna de Mayran, Coahuila, Mexico, Geol. Soc. Am., Bull., vol. 48, no. 12.

———————— (1940A) Neocomian faunas of northern Mexico, Geol. Soc. Am., Bull., vol. 51, pp. 117-190.

———————— (1940B) Lower Cretaceous and Jurassic formations of southern Arkansas, Ark. Geol. Survey, Information circular 12, 64 pages.

———————— (1941) Jurassic fossils from Arkansas, Louisiana, and eastern Texas, Jour. Paleont., vol. 15, no. 3, p. 256.

Ireland, H. A. (1936) Use of insoluble residues for correlation in Oklahoma, Am. Assoc. Petrol. Geol., Bull., vol. 20, p. 1093.

Israelsky, M. C. (1929A) Upper Cretaceous ostracoda of Arkansas, Ark. Geol. Survey, Bull. 2, (extract), 20 pages.

———————— (1929B) Correlation of the Brownstown (restricted) formation of Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 13, no. 6, pp. 683-684.

Jefferson, M. S. W. (1902) Limiting widths of meander belts, Nat. Geogr. Mag., vol. 13, pp. 373-384.

Jennings, P. H. (1936) A microfauna from the Monmouth and basal Rancocas groups of New Jersey, Bull. Am. Paleont., vol. 23, no. 78, 76 pages.

Johnston, L. C. (1877-88) The iron regions of north Louisiana and eastern Texas, House Ex. Doc. 195, 1st Sess., 50th Cong., vol. 26.

Jones, C. T. (1938) Cretaceous and Eocene stratigraphy of Barrilla and eastern Davis Mountains of Trans Pecos, Texas, Am. Assoc. Petrol. Geol., Bull., vol. 22, no. 10, pp. 1423-1440.

Jones, V. H. (1933) Sedimentation in Red River below the mouth of Washita River (Oklahoma), Univ. Iowa Studies in Nat. History, vol. 15, no. 4.

Kane, W. G. and Gierhart, G. B. (1935) Areal geology of Eocene in northeastern Mexico, Am. Assoc. Petrol. Geol., Bull., vol. 19, pp. 1357-1388.

Kellogg, R. (1924) Tertiary pelagic mammals of eastern North America, Geol. Soc. Am., Bull., vol. 35, pp. 755-766.

Kerr, F. F. (1911) Red and Atchafalaya Rivers with relation to their separation from the Mississippi River, Assoc. Eng. Soc., Jour., vol. 46, pp. 185-206.

Kyser, J. S. (1938) The evolution of Louisiana parishes in relation to population growth and movements, Ph. D. dissertation, La. St. Univ., Baton Rouge, La.

Lahee, F. H. (1931) Chestnut dome, Natchitoches Parish, Am. Assoc. Petrol. Geol., Bull., vol. 15, no. 3, pp. 277-278.

Lalicker, C. G. (1935A) New Cretaceous Textulariidae, Cushman Lab. Foram. Res., Contrib., vol. 11, Pt. 1, pp. 1-13.

————————— (1935B) New Tertiary Textulariidae, Cushman Lab. Foram. Res., Contrib., vol. 11, Pt. 2, pp. 39-52.

Langdon, D. W. (1891) Variations in the Cretaceous and Tertiary strata of Alabama, Geol. Soc. Am., Bull., vol. 2.

LeBlanc, R. J. (1941) Correlation of upper Midway fauna of Louisiana (abstract), Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 5, p. 941.

LeBlanc, R. J. and Barry, J. O. (1941) Fossiliferous localities of Midway group in Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 4, pp. 734-737.

LeConte, J. (1877) Hog wallows or prairie mounds, Nature, vol. 15, pp. 530-531.

Leighly, J. B. (1932) Toward a theory of the morphologic significance of turbulence in the flow of water in streams, Univ. Calif. Publ. in Geogr., vol. 6, no. 1, pp. 1-22.

Leversen, A. I. (1927) Convergence studies, Am. Assoc. Petrol. Geol., Bull., vol. 11, pp. 672-673.

Lloyd, A. M. and Blanpied, B. W. (1939) Oil fields of north Louisiana and south Arkansas, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 85.

Lloyd, A. M. and Hazzard, Roy T. (1939) North-South cross section from the Paleozoic outcrops in Howard County, Arkansas, to Beauregard Parish, Louisiana, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 89.

Lockett, S. H. (1871) Second annual report of the topographic survey of Louisiana, La. St. Exp. Sta., Ann. Rept. 1870, New Orleans, 55 pages.

————————— (1872) Fourth annual report of topographical survey of Louisiana, La. St. Univ., Rept., pp. 131-166.

Logan, Jack (1931) Sabine Uplift important in petroleum development, The Oil Weekly, vol. 62, no. 9, pp. 17-20.

Lowe, E. N. (1915) Mississippi, its geology, geography, soils, and mineral resources, Miss. Geol. Survey, Bull. 12.

————————— (1933) Midway and Wilcox groups, in Stephenson, L. W., Cooke, C. W., and Lowe, E. N. (1933) Coastal Plain stratigraphy of Mississippi, Miss. Geol. Survey, Bull. 25, 125 pages.

Lyell, Charles (1889) Principles of geology, 11th ed., vol. 1, New York, Appleton & Co., pp. 440-442, 450-451.

McCoy, A. W. and Keyte, W. R. (1934) Present interpretations of the structural theory for oil and gas migration and accumulation, in Problems of petroleum geology, Am. Assoc. Petrol. Geol., pp. 253-307.

McFarland, L. R. (1939) Garland City pool, Miller County, Arkansas, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 123.

McGuirt, J. H. (1938) Tertiary bryozoa of Louisiana (Ph. D. dissertation), La. St. Univ.

Mahon, Sadie (1925) The micrology of the middle Washita formations, Univ. Texas, Bull. 2544, pp. 67-71.

Marcy, R. B. and McClellan, G. B. (1853) Exploration of the Red River of Louisiana in the year 1852, U. S. 32nd Cong., 2nd sess., Senate Ex. Doc. 54, vol. 8, (U. S. Ser. no. 666), pp. 1-117.

Marshall, R. B. (1916) Spirit leveling in Louisiana, U. S. Geol. Survey, Bull. 634, 101 pages.

Martin, L. T. (1936) Check list of American Cretaceous foraminifera, Edwards Bros., Inc.

Matson, G. C. (1916A) The Caddo oil and gas field, Louisiana and Texas, U. S. Geol. Survey, Bull. 619, 62 pages.

——————— (1916B) The Pliocene Citronelle formation of the Gulf Coastal Plain, U. S. Geol. Survey, Prof. Paper 98 L, pp. 167-192.

——————— (1918) Louisiana clays, U. S. Geol. Survey, Bull. 660 E, pp. 147-158.

Matson, G. C. and Hopkins, O. B. (1918) The DeSoto-Red River oil and gas field, Louisiana, U. S. Geol. Survey, Bull. 661 C, pp. 101-140.

Matthes, F. E. (1933) Cretaceous sediments in Crowleys Ridge, southeastern Missouri, Am. Assoc. Petrol. Geol., Bull., vol. 17, no. 8, p. 1006.

Matthes, G. B. (1933) Diversion of sediment at branching channels, Am. Geophysical Union, Trans., 14th Ann. Meeting, Section of Hydrology, pp. 506-509.

Matthew, W. D. (1924) Correlation of the Tertiary formations of the Great Plains, Geol. Soc. Am., Bull., vol. 35, pp. 743-754.

Meagher, D. P. and Aycock, L. C. (1942) Louisiana lignite, La. Dept. Conserv., Geol. Pamphlet no. 3.

Mellen, F. F. (1939) Winston County mineral resources, Miss. Geol. Survey, Bull. 38, pp. 1-90.

Melton, F. A. (1929A) Natural mounds of northeastern Texas, southern Arkansas, and northern Louisiana, Okla. Acad. Sci., Pr., vol. 9, pp. 119-130.

———— (1929B) Natural mounds of southern Arkansas, north Louisiana, and eastern Texas (abstract), Geol. Soc. Am., Bull., vol. 40, pp. 184-185.

———— (1935) Vegetation and soil mounds, Geogr. Rev., vol. 25, pp. 430-433.

Melton, F. A. and McGuigan, F. H. (1928) The depth of the base of the Trinity sandstone and the present attitude of the Jurassic peneplain in southern Oklahoma, and southwestern Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 12, no. 10.

Mendenhall, W. C. (1935) Discussion of paper by S. A. Thompson on Fredericksburg group of lower Cretaceous, etc., Am. Assoc. Petrol. Geol. Bull., vol. 19, no. 10, p. 1537.

Mineral Industry, The (Published annually by McGraw-Hill from 1892 (1893) to date).

Mineral Resources of the U. S. (Published annually by the U. S. Geol. Survey to 1923, and by the U. S. Bur. Mines from 1924 to date).

Minor, H. E. and Hanna, M. A. (1933) East Texas oil field, Am. Assoc. Petrol. Geol., Bull., vol. 17, no. 7, pp. 757-792.

Miser, H. D. (1920) Geology and general topographic features of Arkansas, in Ferguson, J. G., Outlines of Arkansas geology, pp. 21-42, Little Rock, Ark.

———— (1921) Llanoria, the Paleozoic land area in Louisiana and eastern Texas, Am. Jour. Sci., 5th ser., vol. 2, pp. 61-89.

———— (1927) Lower Cretaceous (Comanche) rocks of southeastern Oklahoma and southwestern Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 11, no. 5, pp. 443-453.

———— (1930) Paleozoic rocks in wells in Gulf Coastal Plain south of Ouachita Mountains (abstract), Pan-Am. Geol., vol. 53, p. 215.

———— (1934) Relation of Ouachita belt of Paleozoic rocks to oil and gas fields of Mid-Continent Region, Am. Assoc. Petrol. Geol., Bull., vol. 18, no. 8, pp. 1059-1077.

Miser, H. D. and Purdue, A. H. (1929) Geology of the DeQueen and Caddo Gap quadrangles, Arkansas, U. S. Geol. Survey, Bull. 808.

Miser, H. D. and Sellards, E. H. (1931) Pre-Cretaceous rocks found in wells in Gulf Coastal Plain south of Ouachita Mountains, Am. Assoc. Petrol. Geol., Bull., vol. 15, pp. 801-818.

Miser, H. D. and Ross, C. S. (1925) Volcanic rocks in the upper Cretaceous of southwestern Arkansas and southwestern Oklahoma, Am. Jour. Sci., vol. 9.

Mix, S. E. and McGlothlin, J. T. (1939) The Shreveport oil field, Caddo Parish, Louisiana, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 118.

Moody, C. L. (1930) Tertiary history of the Sabine uplift (abstract), Pan-Am. Geol., vol. 54, no. 2, pp. 139-140.

——— (1931) Tertiary history of region of the Sabine Uplift, Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 15, no. 5, pp. 531-551.

Moody, C. L. and Moody, J. D. (1939) Cotton Valley field, Webster Parish, Louisiana, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 18.

Moreman, W. L. (1925) Micrology of the Woodbine, Eagle Ford, and Austin chalk, Univ. Texas, Bull. 2544, pp. 74-78.

——— (1927) Fossils zones of the Eagle Ford of north Texas, Jour. Paleont., vol. 1, no. 1, pp. 89-101.

——— (1942) Paleontology of the Eagle Ford group of north and central Texas, Jour. Paleont., vol. 16, no. 2, pp. 192-220.

Morrow, A. L. (1934) Foraminifera and ostracoda from the upper Cretaceous of Kansas, Jour. Paleont., vol. 8, no. 2, pp. 186-205.

Muir, J. M. (1936) Geology of the Tampico region, Mexico, Am. Assoc. Petrol. Geol., Tulsa, Okla.

Murray, Grover, Jr. (1941A) Midway microfauna of northwestern Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 4, pp. 738-742.

——— (1941B) Midway stratigraphy of Sabine Uplift (abstract), Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 5, pp. 941-942.

Murray, Grover, Jr. and Hussey, Keith M. (1942) Some Tertiary ostracoda of the genera Alatacythere and Brachycythere, Jour. Paleont., vol. 16, no. 2, pp. 164-182.

Murray & Thomas

National oil scouts association of America, Yearbook, Gulf Publ. Co., Houston, Tex.

Nickles, John (1931) Bibliography of North American geology, U. S. Geol. Survey, Bulletins.

Northrop, J. D. (1914, published 1915) Petroleum, U. S. Geol. Survey, Mineral Resources, Pt. 2, pp. 893-1092.

Nuttall, W. L. F. (1930) Eocene foraminifera from Mexico, Jour. Paleont., vol. 4, pp. 271-293.

Palmer, D. K. (1934) The upper Cretaceous age of the Orbitoidal genus Gallowayina Ellis, Jour. Paleont., vol. 8, no. 1, pp. 68-69.

Patton, L. (1922) In support of Gardner's theory of the origin of certain concretions, Jour. Geol., vol. 33.

Penrose, R. A. F., Jr. (1890) A preliminary report on the geology of the Gulf Tertiary of Texas from Red River to Rio Grande, Texas Geol. Survey, 1st Ann. Rept., pp. 19-25, 58-60.

Piper, C. V. (1905) The basalt mounds of the Columbia lava, Science, vol. 21, no. 543, pp. 824-825.

Plummer, F. B. (1932) Cenozoic systems of Texas, Univ. Texas, Bull. 3232, Pt. 3, pp. 519-606, 809-818.

Plummer, F. B. and Plummer, H. J. (1928) Midway correlations on the basis of foraminifera (abstract), Pan-Am. Geol., vol. 49, no. 4, p. 297; Geol. Soc. Am., Bull., vol. 39, no. 1, p. 278.

Plummer, F. B. and Sargent, E. C. (1930) Map of northeast Texas showing structural conditions and extent of Woodbine formation, Univ. Texas, Bureau of Econ. Geol.

———— ———— (1931) Woodbine sand of northeast Texas, Univ. Texas, Bull. 3138.

Plummer, H. J. (1926) Foraminifera of the Midway formation in Texas, Univ. Texas, Bull. 2644, 206 pages.

———— (1931A) Gaudryinella, a new foraminiferal genus, Am. Midland Nat., vol. 12, pp. 341-342.

———— (1931B) Some Cretaceous foraminifera in Texas, Univ. Texas, Bull. 3101, pp. 109-203.

———— (1932A) Ammobaculites, a new foraminiferal genus, Am. Midland Nat., vol. 13, pp. 86-88.

———— (1932B) Foraminiferal evidence of the Midway-Wilcox contact in Texas, Univ. Texas, Bull. 3201, pp. 51-68.

Plummer Bull 3232

———— (1934) Epistominoides and Coleites, new genera of foraminifera, Am. Midland Nat., vol. 15, no. 5, pp. 601-608.

———— (1936) Microscopical evidence of the Navarro-Taylor contact in subsurface sections in central Texas, Univ. Texas, Bull. 3501, pp. 281-292.

———— (1938) Adhaerentia, a new foraminiferal genus, Am. Midland Nat., vol. 15, no. 5, pp. 601-608.

Ponton, G. M. and Whitehurst, J. W. (1923) The Spring Hill-Sarepta gas field, Webster and Bossier Parishes, Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 7, no. 5.

Powers, Sidney (1920) The Sabine Uplift, Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 4, no. 2, pp. 117-136.

—————————— (1926) Interior salt domes of Texas, Am. Assoc. Petrol. Geol., Bull., vol. 10, no. 1, pp. 1-60; Geology of salt dome oil fields, Am. Assoc. Petrol. Geol., Tulsa, Okla., pp. 209-268.

—————————— (1928) Age of the folding of the Oklahoma Mountains — the Ouachita, Arbuckle, and Wichita Mountains — of Oklahoma and the Llano, Burnet, and Marathon Uplifts of Texas, Geol. Soc. Am., Bull., vol. 39, pp. 1031-1072.

Purdue, A. H. (1905) Concerning the natural mounds, Science, vol. 21, no. 543, pp. 823-824.

Purzer, Joseph (1939) Northeast-southwest cross section, Cleveland County, Arkansas, to Webster Parish, Louisiana, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 114.

Read, W. A. (1927) Louisiana place names of Indian origin, La. St. Univ., Bull., n. s., vol. 19, no. 2.

Reeside, J. B., Jr. (1927) The Scaphites, an upper Cretaceous ammonite group, U. S. Geol. Survey, Prof. Paper 150, pp. 21-40.

——————————(1931) The upper Cretaceous ammonite genus Barroisiceras in the United States, U. S. Geol. Survey, Prof. Paper 170, pp. 9-29.

Renevier, M. E. (1901) Commission Internationale de classification stratigraphique (committee rept.), Internat. Géol. Cong., 8th sess., Paris, Comptes rendus, Pt. 1, pp. 192-203.

Rich, J. L. (1934) Soil mottlings and mounds in northeastern Texas as seen from the air, Geol. Rev., vol. 24, pp. 576-583.

—————————— (1935) Graphical method for eliminating regional dip, Am. Assoc. Petrol. Geol., Bull., vol. 19, no. 10, pp. 1538-1540.

Richardson, G. B. (1921) (Map of the) Oil and gas fields of the state of Louisiana, U. S. Geol. Survey.

Ring, D. T. (1926) Review of petroleum industry in Arkansas and Louisiana during 1925, in Petroleum development and technology in 1925, Am. Inst. Min. Metall. Eng., New York, pp. 609-621.

Roberts, J. K. (1928) Tertiary stratigraphy of western Tennessee, Geol. Soc. Am., Bull., vol. 39, no. 2.

Roemer, F. (1846) A sketch of the geology of Texas, Am. Jour. Sci., 2nd ser., vol. 2, pp. 358-365.

—————————— (1888) Macraster, eine neue Spatangoiden-Gattung aus der Kreide von Texas, Neues Jahrbuch 1887, pp. 191-195.

Ross, C. S., Miser, H. D., and Stephenson, L. W. (1929) Waterlaid volcanic rocks of early upper Cretaceous age in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas, U. S. Geol. Survey, Prof. Paper 154, pp. 175-202.

Roy, C. J. and Glockzin, A. R. (1941) Tentative correlation chart of Gulf Coast, Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 4, pp. 742-746.

Rubey, W. M. (1922) Wildcat oil exploration in south-central Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 6, no. 4, pp. 350-358.

Russell, I. C. (1898) Rivers of North America, G. P. Putnam's Sons, 327 pages.

Russell, R. J. (1936) Physiography of lower Mississippi River delta, in Lower Mississippi River delta, La. Dept. Conserv., Geol. Bull. 8, pp. 1-199.

——————— (1938) Geology of Iberville and Ascension Parishes, La. Dept. Conserv., Geol. Bull. 13, pp. 1-86.

——————— (1939) Louisiana stream patterns, Am. Assoc. Petrol. Geol., Bull., vol. 23, no. 8, pp. 1199-1227.

Safford, J. M. (1864) On the Cretaceous and Superior formations of west Tennessee, Am. Jour. Sci., 2nd ser., vol. 37, pp. 360-372.

Sample, C. H. (1932) Cribratina, a new genus of foraminifera from the Comanchean of Texas, Am. Midland Nat., vol. 13, pp. 319-322.

Sandidge, J. R. (1928) The recurrent brachiopods of the lower Cretaceous of northern Texas, Am. Jour. Sci., 5th ser., vol. 15, pp. 314-318.

——————— (1932A) Fossil foraminifera from the Cretaceous, Ripley formation, of Alabama, Am. Midland Nat., vol. 13, pp. 312-318.

——————— (1932B) Foraminifera from the Ripley formation of western Alabama, Jour. Paleont., vol. 6, no. 3, pp. 365-387.

——————— (1932C) Significant foraminifera from the Ripley formation of Alabama, Am. Midland Nat., vol. 13, no. 4, pp. 190-203.

——————— (1932D) Additional foraminifera from the Ripley formation in Alabama, Am. Midland Nat., vol. 13, no. 6, pp. 333-337.

Schenck, H. G. (1935) What is the Vaqueros formation of California and is it Oligocene?, Am. Assoc. Petrol. Geol., Bull., vol. 19, pp. 521-536.

Schuchert, Charles (1910) Paleogeography of North America, Geol. Soc. Am., Bull., vol. 20, pp. 427-606.

——————— (1916) Correlation and chronology in geology on the basis of paleogeography, Geo. Soc. Am., Bull., vol. 27, pp. 491-

———————— (1919) The relations of stratigraphy and paleogeography to petroleum geology, Am. Assoc. Petrol. Geol., Bull., vol. 3, pp. 286-298.

———————— (1923) Sites and nature of the North American geosynclines, Geol. Soc. Am., Bull., vol. 34, pp. 151-229.

———————— (1929) Geological history of the Antillean Region, Geol. Soc. Am., Bull., vol. 40, pp. 337-360.

———————— (1935) Historical geology of the Antillean-Caribbean Region or the lands bordering the Gulf of Mexico and the Caribbean Sea, New York, John Wiley & Sons, pp. 220-242, 275-283.

Scott, Gayle (1926A) A new correlation of the Texas Cretaceous, Am. Jour. Sci., 5th ser., vol. 12, no. 17.

———————— (1926B) Études stratigraphiques et paléontologiques sur les terrains Cretacés du Texas, Grenoble Univ., Annales, n. s., sec. sci., vol. 3, pp. 93-210.

———————— (1926C) On a new correlation of the Texas Cretaceous, Am. Jour. Sci., 5th ser., vol. 12, pp. 157-161.

———————— (1926D) The Woodbine sand of Texas interpreted as a regressive phenomenon, Am. Assoc. Petrol. Geol., Bull., vol. 10, no. 6, pp. 613-634.

———————— (1928) Ammonites of the genus Dipoloceras, and a new Hamite from the Texas Cretaceous, Jour. Paleont., vol. 2, pp. 108-118.

———————— (1934) Age of the Midway Group, Geol. Soc. Am., Bull., vol. 45, pp. 1111-1158.

Scott, Gayle and Moore, M. H. (1928) Ammonites of enormous size from the Texas Cretaceous, Jour. Paleont., vol. 2, pp. 273-278.

Sellards, E. H. (1932) Bibliography and subject index of Texas geology, Univ. Texas, Bull. 3232, Pt. 4, pp. 819-965.

Sellards, E. H., Adkins, W. S., and Plummer, F. B. (1932) Geology of Texas, Stratigraphy, Univ. Texas, Bull. 3232, vol. 1.

Sellards, E. H. and Baker, C. L. (1934) The geology of Texas, Structural and economic geology, Univ. Texas, Bull. 3401, vol. 2.

Shaw, J. A. (1929) Report of the division of minerals, La. Dept. Conserv., 9th Biennial Rept., pp. 140-184.

———————— (1931) Report of the division of minerals (1930-31), La. Dept. Conserv., 10th Biennial Rept., pp. 395-478.

———————— (1933A) A brief survey of the mineral resources of Louisiana, La. Dept. Conserv., Gen. Minerals Bull. 22, pp. 31-125.

———————— (1933B) Report of the division of minerals, La. Dept. Conserv., 11th Biennial Rept., pp. 346-466.

———————— (1936A) Mineral production of Louisiana, 1934 and 1935, La. Dept. Conserv., Gen. Minerals Bull. 27, pp. 51-146.

———————— (1936B) Report of the division of minerals (1934-35), La. Dept. Conserv., 12th Biennial Rept., pp. 378-517.

Shearer, H. K. (1932) Oil and gas developments in south Arkansas, north Louisiana, and Mississippi in 1931, in Petroleum development and technology in 1932, Am. Inst. Min. Metall. Eng., Trans., pp. 159-164.

———————— (1938A) Developments in south Arkansas and north Louisiana in 1937, Am. Assoc. Petrol. Geol., Bull., vol. 22, no. 6.

———————— (1938B) Oil and gas development in north Louisiana in 1937, in Petroleum development and technology, Am. Inst. Min. Metall. Eng., vol. 127, pp. 413-425.

———————— (1939) Oil and gas development in north Louisiana in 1938, Am. Inst. Min. Metall. Eng., Trans., vol. 132, pp. 340-351.

Shepard, E. M. (1905) The New Madrid earthquake, Jour. Geol., vol. 13, pp. 45-62.

Shepard, F. P. (1932) Sediments of the continental shelves, Geol. Soc. Am., Bull., vol. 43, p. 1038.

[illegible]

Simpson, G. C. (1932) A new Paleocene mammal from a deep well in Louisiana, U. S. Nat. Mus., Pr., vol. 82, art. 4, pp. 1-4.

Smiser, J. S. (1931) The value of fossil fragments, Jour. Paleont., vol. 5, pp. 293-295.

———————— (1933) A study of the echinoid fragments in the Cretaceous rocks of Texas, Jour. Paleont., vol. 7, no. 2, pp. 123-163.

———————— (1936) Cretaceous echinoids from Trans Pecos, Texas, Jour. Paleont., vol. 10, no. 6, pp. 449-480.

Smith, Burnett (1906) Phylogeny of the races of Volutilithes petrosus, Acad. Nat. Sci. Philadelphia, Pr., vol. 53, pp. 52-76.

Smith, E. A. (1892A) Sketch of geology of Alabama, Roberts & Son, Birmingham, Ala., 36 pages.

———————— (1892B) Alabama Geol. Survey, Bull. 2.

Smith, E. A., Langdon, D. W., Jr., and Johnson, L. C. (1894) Report on the geology of the coastal plain of Alabama, Alabama Geol. Survey.

Smith, E. A. and Aldrich, T. H. (1886) Alabama Geol. Survey, Bull. 1.

Smith, E. A. and Johnson, L. C. (1887) On the Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers, U. S. Geol. Survey, Bull. 43, pp. 167-337.

Sonderegger, V. H. (1933) Classification and uses of agricultural and forest lands in the state of Louisiana, and the parishes, La. Dept. Conserv., Division of Forestry, Bull. 24.

Sparagen, L. (1929) Magnetometer survey of Louisiana, Oil and Gas. Jour., vol. 27, no. 46, pp. 103, 110, continued in vol. 27, no. 48, pp. 85, 96, 99.

Spillman, W. J. (1905) Natural mounds, Science, vol. 21, no. 538, p. 632.

Spooner, W. C. (1926) Interior salt domes of Louisiana, Am. Assoc. Petrol. Geol., Bull., vol. 10, pp. 217-292.

————— (1928) Geology of the Gulf Coastal Plain of Arkansas and Louisiana, Geol. Soc. Am., Bull., vol. 39, no. 1, pp. 274-275.

————— (1932) Salt in the Smackover field, Union County, Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 16, no. 6, pp. 601-608.

————— (1935) Oil and gas geology of Gulf Coastal Plain in Arkansas, Ark. Geol. Survey, Bull. 2, Park-Harper Printing Co., Little Rock, Ar., 516 pages.

————— (1939) Development in southern Arkansas and Louisiana in 1938, Shreveport Geol. Soc., Guide Book, 14th Ann. Field Trip, p. 71.

Stanton, T. W. (1897) A comparative study of the lower Cretaceous formations and faunas of the United States, Jour. Geol., vol. 5, pp. 579-624.

————— (1927) The Cretaceous of Texas, Am. Jour. Sci., 5th ser., vol. 13, pp. 517-522.

————— (1928) The lower Cretaceous or Comanche series, Am. Jour. Sci., 5th ser., vol. 16, pp. 399-409; (abstract), Geol. Soc. Am., Bull., vol. 39, no. 1, p. 276; Pan-Am. Geol., vol. 49, no. 3, p. 240.

Stafanni, G. (1924) Relations between American and European Tertiary echinoid faunas, Geol. Soc. Am., Bull., vol. 35, pp. 827-864.

Stephenson, L. W. (1914) Species of Exogyra from the eastern Gulf region and the Carolinas, U. S. Geol. Survey, Prof. Paper 81, 77 pages.

————— (1914, Publ. 1915) The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain, U. S. Geol. Survey, Prof. Paper 90, pp. 150-182.

————— (1926) Major features in the geology of the Atlantic and Gulf Coastal Plain, Wash. Acad. Sci., Jour., vol. 16, no. 17, pp. 460-480.

————— (1927) Notes on the stratigraphy of the upper Cretaceous formations of Texas and Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 11, no. 1, pp. 1-17.

————— (1928A) Major marine transgressions and regressions and structural features of the Gulf Coastal Plain, Am. Jour. Sci., 5th ser., vol. 16, pp. 281-298; (abstract), Pan-Am. Geol., vol. 49, no. 4, pp. 301-302; (abstract), Geol. Soc. Am., Bull., vol. 39, no. 1, pp. 275-276.

————— (1928B) Correlation of the upper Cretaceous or Gulf series of the Gulf Coastal Plain, Am. Jour. Sci., 5th ser., vol. 16, pp. 485-496.

————— (1928C) Structural features of the Atlantic and Gulf Coastal Plain, Geol. Soc. Am., Bull., vol. 39, pp. 887-900.

————— (1929A) Age of the Brownstown marl of Arkansas, Am. Assoc. Petrol. Geol., Bull., vol. 13, no. 8, pp. 1073-1074.

————— (1929B) Unconformities in upper Cretaceous series of Texas, Am. Assoc. Petrol. Geol., Bull., vol. 13, no. 10, pp. 1323-1334.

————— (1929C) Two new mollusks of the genera Ostrea and Exogyra from the Austin chalk, Texas, U. S. Nat. Mus., Pr. 76, art. 18, pp. 1-6.

————— (1933) The zone of Exogyra cancellata traced 2,000 miles, Am. Assoc. Petrol. Geol., Bull., vol. 17, pp. 1351-1361.

————— (1937) Stratigraphic relations of the Austin, Taylor, and equivalent formations in Texas, U. S. Geol. Survey, Prof. Paper 186 G.

————— (1941) Summary of faunal studies of Navarro group of Texas, Am. Assoc. Petrol. Geol., Bull., vol. 25, no. 4, pp. 637-643.

Stephenson, L. W. and Monroe, W. H. (1938) Stratigraphy of upper Cretaceous series in Mississippi and Alabama, Am. Assoc. Petrol. Geol., Bull., vol. 22, no. 12, pp. 1639-1657.

————— ————— (1940) The upper Cretaceous deposits, Miss. Geol. Survey, Bull. 40, 296 pages.

Stephenson, L. W. and Reeside, J. B., Jr. (1938) Comparison of upper Cretaceous deposits of Gulf region and western Interior region, Am. Assoc. Petrol. Geol., Bull., vol. 22, no. 12, pp. 1629-1638.

Stone, R. W. (1918) The DeSoto-Red River oil and gas field, Louisiana, (abstract), Wash. Acad. Sci., Jour., vol. 8, pp. 36-37.

Sum... 1948

Takahashi, J. and Jagi, T. (1929) Peculiar mud grains and their relation to the origin of glauconite, Econ. Geol., vol. 24, pp. 838-852.

Teas, L. P. (1923) Differential compacting the cause of certain Claiborne dips (in the north Louisiana-south Arkansas district) (with discussion), Am. Assoc. Petrol. Geol., Bull., vol. 7, no. 4, pp. 370-387.

——————— (1927) Tertiary production (written discussion), in Petroleum development and technology in 1926, Am. Inst. Min. Metall. Eng., pp. 681-684.

——————— (1928) Review of petroleum development in Arkansas and north Louisiana in 1927, in Petroleum development and technology in 1927, Am. Inst. Min. Metall. Eng., New York, pp. 666-675.

——————— (1929) Bellevue oil field, Bossier Parish, Louisiana, in Structure of typical American oil fields, vol. 2, pp. 229-253, Tulsa, Okla.

Thomas, N. L. and Rice, E. M. (1931A) Notes on the Saratoga chalk, Jour. Paleont., vol. 5, no. 4, pp. 316-328.

——————— ——————— (1931B) Cretaceous chalks of Arkansas and Texas, Am. Assoc. Petrol. Geol.,Bull., vol. 15, geological notes.

——————— ——————— (1932) Notes on the Annona chalk, Jour. Paleont., vol. 6, no. 4, pp. 319-329.

Thompson, S. A. (1935) Fredericksburg group of lower Cretaceous with special reference to north-central Texas, Am. Assoc. Petrol. Geol., Bull., vol. 19, no. 10, pp. 1508-1537.

Thompson, W. C. (1922) The Midway limestone of northeast Texas, Am. Assoc. Petrol. Geol., Bull., vol. 6, no. 4, pp. 323-332.

Toulmin, Lyman D. (1940A) Eocene brachiopods from the Salt Mountain limestone of Alabama, Jour. Paleont., vol. 14, no. 3, pp. 227-233.

——————— (1940B) The Salt Mountain limestone of Alabama, Alabama Geol. Survey, Bull. 46, 126 pages.

——————— (1941) Eocene smaller foraminifera from the Salt Mountain limestone of Alabama, Jour. Paleont., vol. 15, no. 6, pp. 567-611.

Trowbridge, A. C. (1923) A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande, U. S. Geol. Survey, Prof. Paper 131 D.

——————— (1932) Tertiary and Quaternary geology of the lower Rio Grande region, Texas, U. S. Geol. Survey, Bull. 837, 260 pages.

Twenhofel, W. H. (1926) Treatise on sedimentation, Baltimore, Md.

Udden, J. A. (1906) The origin of the small sand mounds in the Gulf Coast country, Science, vol. 23, no. 596, pp. 849-851.

———— (1914) Mechanical composition of clastic sediments, Geol. Soc. Am., Bull., vol. 25, pp. 655-744.

Van der Gracht, W. A. J. M. van Waterschoot (editor) (1928) Theory of continental drift, Am. Assoc. Petrol. Geol., Tulsa, Okla.

Vanderpool, H. C. (1928A) Fossils from the Trinity group (lower Comanchean), Jour. Paleont., vol. 2, no. 2, pp. 95-107.

———— (1928B) A preliminary study of the Trinity group in southwestern Arkansas, southeastern Oklahoma, and northern Texas, Am. Assoc. Petrol. Geol., Bull., vol. 12, no. 11, pp. 1069-1094.

———— (1932) Microfossils from upper part of Trinity beds near Marietta, Oklahoma, (abstract), Pan-Am. Geol., vol. 57, p. 317.

———— (1933) Upper Trinity microfossils from southern Oklahoma, Jour. Paleont., vol. 7, no. 4, pp. 406-412.

Vaughan, T. W. (1893) Notes on a collection of mollusks from northwestern Louisiana, and Harrison County, Texas, Am. Nat., vol. 27, pp. 944-961.

———— (1895A) Section of the Eocene at old Port Caddo Landing, Harrison County, Texas, with notes upon a collection of plants from that locality by F. H. Knowlton, Am. Geol., vol. 16, pp. 304-309.

———— (1895B) The stratigraphy of northwestern Louisiana, Am. Geol., vol. 15, pp. 205-229.

———— (1896) A brief contribution to the geology and paleontology of northwestern Louisiana, U. S. Geol. Survey, Bull. 142, 65 pages.

———— (1900) The Eocene and lower Oligocene coral faunas of the United States, U. S. Geol. Survey, Mon. 39, 263 pages.

———— (1903) The corals of the Buda limestone, U. S. Geol. Survey, Bull. 205, pp. 37-40.

———— (1918) Correlation of the Tertiary geologic formations of the southeastern United States, Central America, and the West Indies, Wash. Acad. Sci., Jour., vol. 8, pp. 286-287.

———— (1924A) American and European Tertiary corals, Geol. Soc. Am., Bull., vol. 35, pp. 823-826.

———— (1924B) American and Tertiary larger foraminifera, Geol. Soc. Am., Bull., vol. 35, pp. 785-822.

——————— (1924C) Criteria and status of correlation and classification of Tertiary deposits, Geol. Soc. Am., Bull., vol. 35, pp. 677-742.

——————— (1929) Species of Orbitocyclina, a genus of American Orbitoid foraminifera from the upper Cretaceous of Mexico and Louisiana, Jour. Paleont., vol. 3, no. 2, pp. 170-175.

——————— (1934) A note on Orbitoides brownii (Ellis) Vaughan, Jour. Paleont., vol. 8, no. 1, pp. 70-72.

——————— (1936) New species of Orbitoidal foraminifera of the genus Discocyclina from the lower Eocene of Alabama, Jour. Paleont., vol. 10, pp. 253-259.

——————— (1941) New corals: one Recent, Alaska; three Eocene, Alabama and Louisiana, Jour. Paleont., vol. 15, no. 3, pp. 280-284.

Vaughan, T. W. and Cole, W. S. (1932) Cretaceous Orbitoidal foraminifera from the Gulf States and Central America, Nat. Acad. Sci., Pr., vol. 18, pp. 611-616.

Veatch, A. C. (1899) The Shreveport area, La. St. Exp. Sta., La. Geol. Survey, Rept., pp. 149-208.

——————— (1902A) A preliminary report on the geology of Louisiana, La. St. Exp. Sta., Geol. Agr. La., Pt. 5, p. 354.

——————— (1902B) The geology and geography of the Sabine River, La. St. Exp. Sta., Geol. Agr. La., Pt. 6, Spec. Rept. 3, pp. 107-141.

——————— (1905A) A dictionary of altitudes in northern Louisiana, Appendix to Bull. 1, Pt. 2, La. Geol. Survey, Rept. of 1905.

——————— (1905B) The question of the origin of the natural mounds of Louisiana, (abstract), Science, vol. 21, no. 531, pp. 350-351.

——————— (1905C) Underground waters of eastern United States, Louisiana and southern Arkansas, U. S. Geol. Survey, W. S. Paper 114, pp. 179-187.

——————— (1905D) The underground waters of northern Louisiana and southern Arkansas, La. Geol. Survey, Bull. 1, Pt. 2, Rept. of 1905.

——————— (1906A) Geology and underground water resources of northern Louisiana and southern Arkansas, U. S. Geol. Survey, Prof. Paper 46, 422 pages.

——————— (1906B) Geology and underground water resources of northern Louisiana, La. Geol. Survey, Bull. 4, pp. 249-514.

———————— (1906C) On the human origin of the small mounds of the lower Mississippi valley and Texas, Science, vol. 23, no. 575, pp. 34-36.

Veatch, A. C. and others (1906) Underground water resources of Long Island, New York, U. S. Geol. Survey, Prof. Paper 44, 394 pages.

Veatch, Otto and Stephenson, L. W. (1911) Geology of the Coastal Plain of Georgia, Ga. Geol. Survey, Bull., vol. 26, pp. 35-39.

Ver Wiebe, W. A. (1929) Tectonic classification of oil fields in the United States, Am. Assoc. Petrol. Geol., Bull., vol. 13, no. 5, pp. 409-440.

———————— (1931) Oil fields of the United States, McGraw-Hill Book Co., New York.

Wailes, B. L. C. (1854) Report on the agriculture and geology of Mississippi, E. Barksdale, Jackson, Miss.

Weeks, A. W. (1933) Lissie, Reynosa, and upland terrace deposits of Coastal Plain of Texas between Brazos River and Rio Grande, Am. Assoc. Petrol. Geol., Bull., vol. 17, pp. 453-487.

Weeks, W. B. (1938) South Arkansas stratigraphy with emphasis on the older Coastal Plain beds, Am. Assoc. Petrol. Geol., Bull., vol. 22, no. 8, pp. 953-983.

Weller, J. M. (1930) Cyclical sedimentation of the Pennsylvania period and its significance, Jour. Geol. vol. 38, pp. 97-135.

———————— (1931) Sedimentary cycles in the Pennsylvania strata: a reply, Am. Jour. Sci., 5th ser., vol. 21, pp. 311-329.

Weller, S. (1907) A report on the Cretaceous paleontology of New Jersey, N. J. Geol. Survey, Paleont., vol. 4, pp. 189-265.

Wells, J. W. (1932) Corals of the Trinity group of the Comanchean of central Texas, Jour. Paleont., vol. 6, pp. 225-256.

White, C. A. (1883) A review of the fossil Ostreidae of North America, U. S. Geol. Survey, Ann. Rept. 4, pp. 273-430.

———————— (1888) On the Cretaceous formations of Texas and their relation to those of other portions of North America, Acad. Nat. Sci. Philadelphia, Pr., 1887.

White, M. P. (1928) Some index foraminifera of the Tampico embayment area of Mexico, Jour. Paleont., vol. 2, no. 3, pp. 177-215.

Whittemore, J. W. (1927) The clays of Louisiana (Shreveport area), La. Dept. Conserv., Bull. 14, 84 pages.

Willis, Bailey (1907) A theory of continental structure applied to North America, Geol. Soc. Am., Bull., vol. 18, pp. 389-412.

———————— (1920) Discoidal structure of the lithosphere, Geol. Soc. Am., Bull., vol. 31, pp. 247-302.

———————— (1929) Continental genesis, Geol. Soc. Am., Bull., vol. 40, pp. 281-336.

Wilmarth, M. Grace (1925) The geologic time classification of the United States Geological Survey compared with other classifications, U. S. Geol. Survey, Bull. 769, 138 pages.

———————— (1938) Lexicon of geologic names of the United States, U. S. Geol. Survey, Bull. 896, 2396 pages.

Woodward, T. P. and Gueno, Albert (1941) The sand and gravel deposits of Louisiana, La. Dept. Conserv., Geol. Bull. 19, pp. 1-365.

Wrather, W. E. and Lakee, F. H. (editors) (1934) Problems of petroleum geology, Am. Assoc. Petrol. Geol., Tulsa, Okla., 1073 pages.

AUTOBIOGRAPHY

Grover Murray, Jr., was born in Maiden, North Carolina, October 26, 1916. He attended Newton Grammar and High Schools from 1923 to 1933. He entered the University of North Carolina in 1933 and was graduated with a B. S. degree in Geology in 1937. He received the M. S. degree in Geology from Louisiana State University in 1939 and completed the requirements for the Ph. D. degree in 1941. He is a member of the North Carolina Academy of Science, the American Association for the Advancement of Science, the Sigma Xi Society, the American Association of Petroleum Geologists, the Mississippi Geological Society, and the Society of Economic Paleontologists and Mineralogists. He held a teaching fellowship in the School of Geology, Louisiana State University, from 1937 to 1938, and a research fellowship with the Louisiana Geological Survey from 1938 to 1941. He has been employed by the Magnolia Petroleum Company since July, 1941.

GEOLOGY OF DESOTO AND RED RIVER PARISHES, LOUISIANA

Abstract

DeSoto and Red River Parishes are in northwestern Louisiana in the drainage basins of the Red and Sabine Rivers. They are in the outcrop belt of the Midway and Sabine (Wilcox) sediments exposed near the center of the Sabine Uplift.

Investigations were conducted in the parishes in order to prepare for the Louisiana Geological Survey a geological map and report on the parishes and to determine, if possible, the stratigraphic subdivisions of the sediments exposed in this area. Detailed surface investigations were carried out in the field and were augmented by laboratory studies involving both surface and subsurface data.

Three topographic provinces exist in the parishes. These are the alluvial valleys or flood plains, the Prairie terrace, and the uplands or hill areas, which are divisible into terrace uplands and Tertiary uplands.

The floodplain areas are divisible into two main parts, namely, (1) natural levee areas, and (2) areas of backwater flooding. The (Pleistocene) terraces are represented by four alluvial surfaces to which the names Prairie, Montgomery, Bentley, and Williana have been applied in order from youngest to oldest. These terrace surfaces are underlain by alluvial deposits to which the Prairie, Montgomery, Bentley, and Williana are applied as formational names.

The Tertiary surface deposits of DeSoto and Red River Parishes, formerly included in the Mansfield sub-group of the Sabine (Wilcox) group, are assigned to the upper portion of the Midway group (Paleocene) and

the lower portion of the Sabine group (lower Eocene). Borings for oil and gas in these parishes have penetrated upper and lower Cretaceous deposits.

The surface deposits of these parishes are divided into four new formations and six new members. These are:

Tertiary system
- Eocene series
  - Sabine group
    - Marthaville formation
- Paleocene series
  - Midway group
    - Hall Summit formation
      - Bisteneau member
      - Grand Bayou member
      - Loggy Bayou member
    - Logansport formation
      - Lime Hill member
      - Cow Bayou member
      - Dolet Hills member
    - Naborton formation

The surface mapping in this area indicates that the DeSoto-Red River-Bull Bayou uplift is the highest structural portion of the Sabine Uplift when mapped on the Tertiary. In addition, surface mapping indicates the presence of twelve other structural highs in the vicinity of DeSoto and Red River Parishes. Eight of these structures have produced oil or gas.

Lists of fossils observed in the subsurface formations; check lists of the fossil forms observed in the surface sediments; statistical charts of oil and gas production; nine plates, fourteen cross sections and figures, and forty-two photographs illustrate and complete the written discussions. Appendices describe the general character of the soils in the parishes and list the most important fossil localities.

EXAMINATION AND THESIS REPORT

Candidate: Grover Murray, Jr.

Major Field: Geology

Title of Thesis: Geology of DeSoto and Red River Parishes, Louisiana

Approved:

Harold N. Fisk

Major Professor and Chairman

Wm O Scroggs

Dean of the Graduate School

EXAMINING COMMITTEE:

H. V. Howe

Chalmer J. Roy

Richard Joel Russell

Benjamin C. Craft

C. A. Brown

Date of Examination:

April 28, 1942

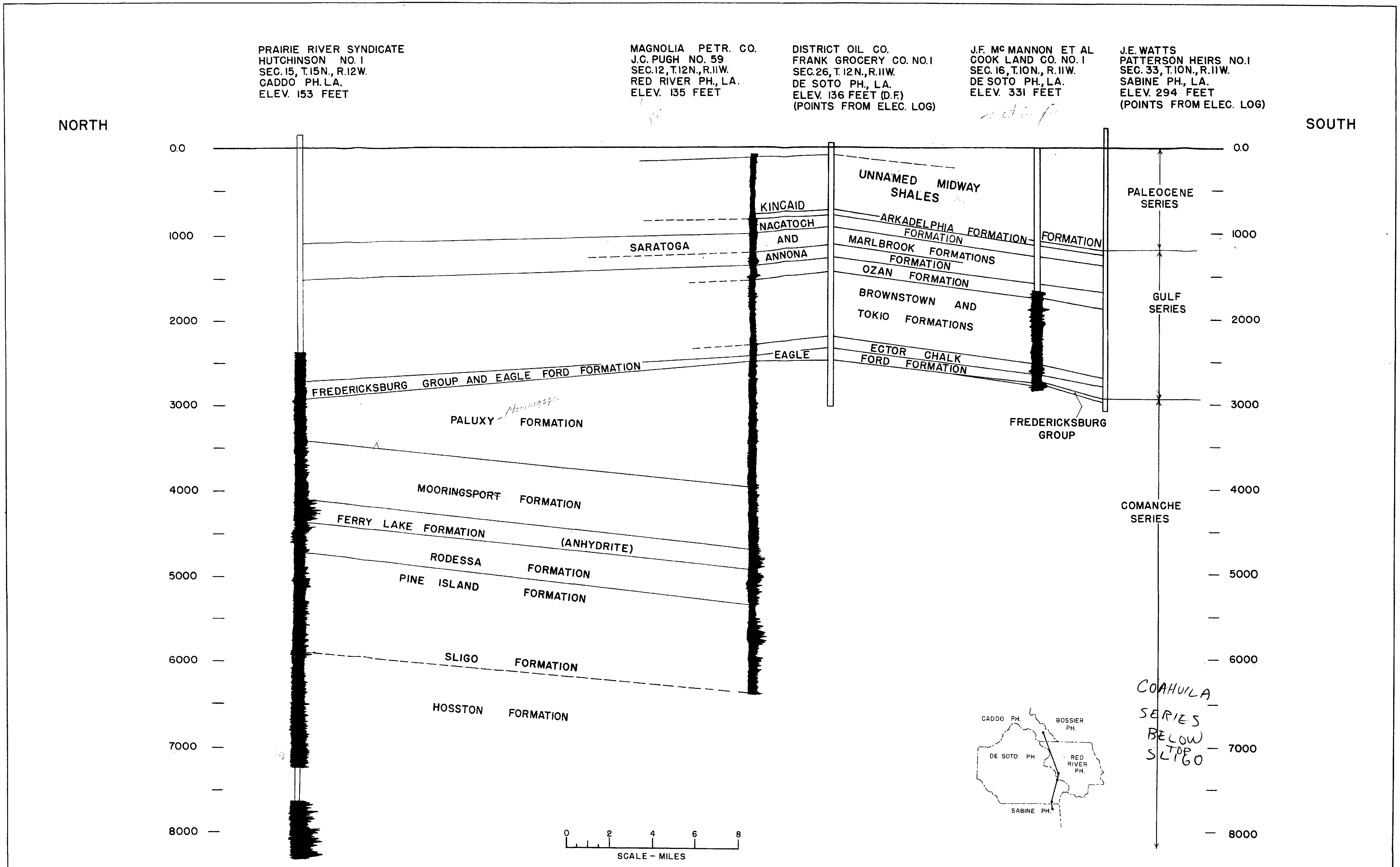
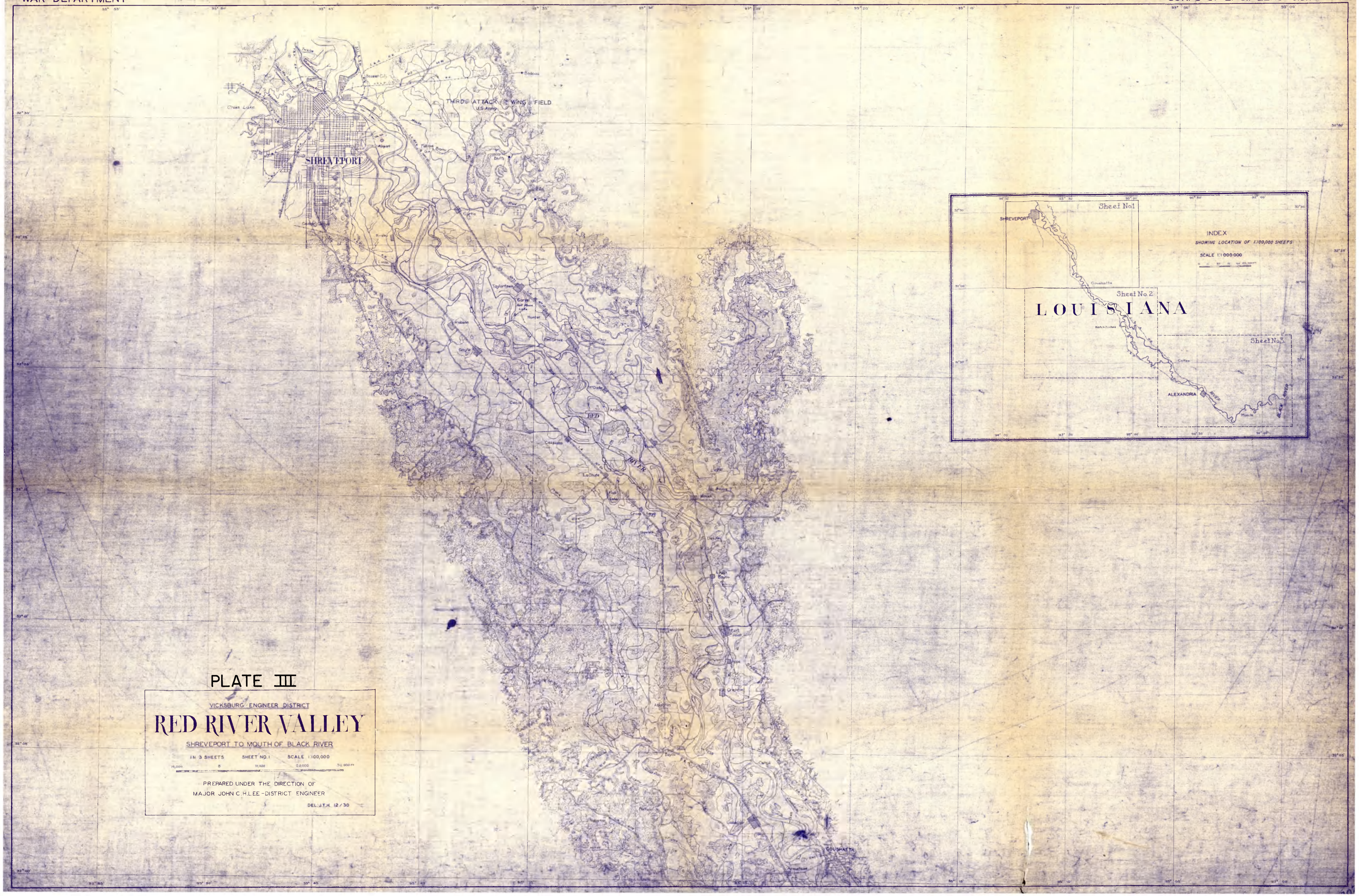


FIGURE 9. NORTH-SOUTH CROSS SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

FIGURE 9. NORTH-SOUTH CROSS SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY



WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY

PLATE III

VICKSBURG ENGINEER DISTRICT

RED RIVER VALLEY

SHREVEPORT TO MOUTH OF BLACK RIVER

IN 3 SHEETS SHEET NO. 1 SCALE 1:100,000

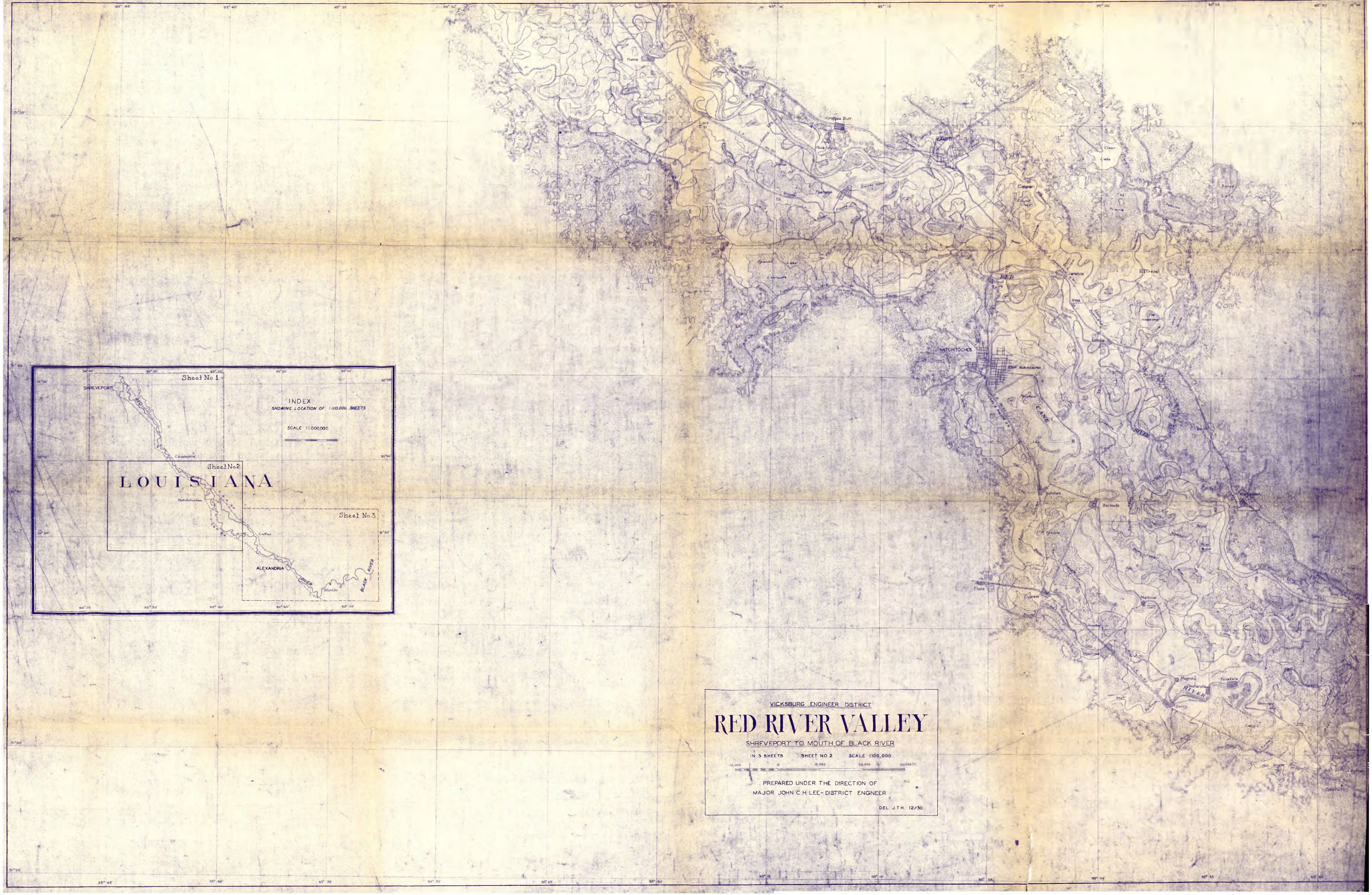
10,000 0 10,000 20,000 30,000 Ft

PREPARED UNDER THE DIRECTION OF
MAJOR JOHN C.H. LEE - DISTRICT ENGINEER

DEL: J.T.H. 12/30

WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY



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Pl. III.

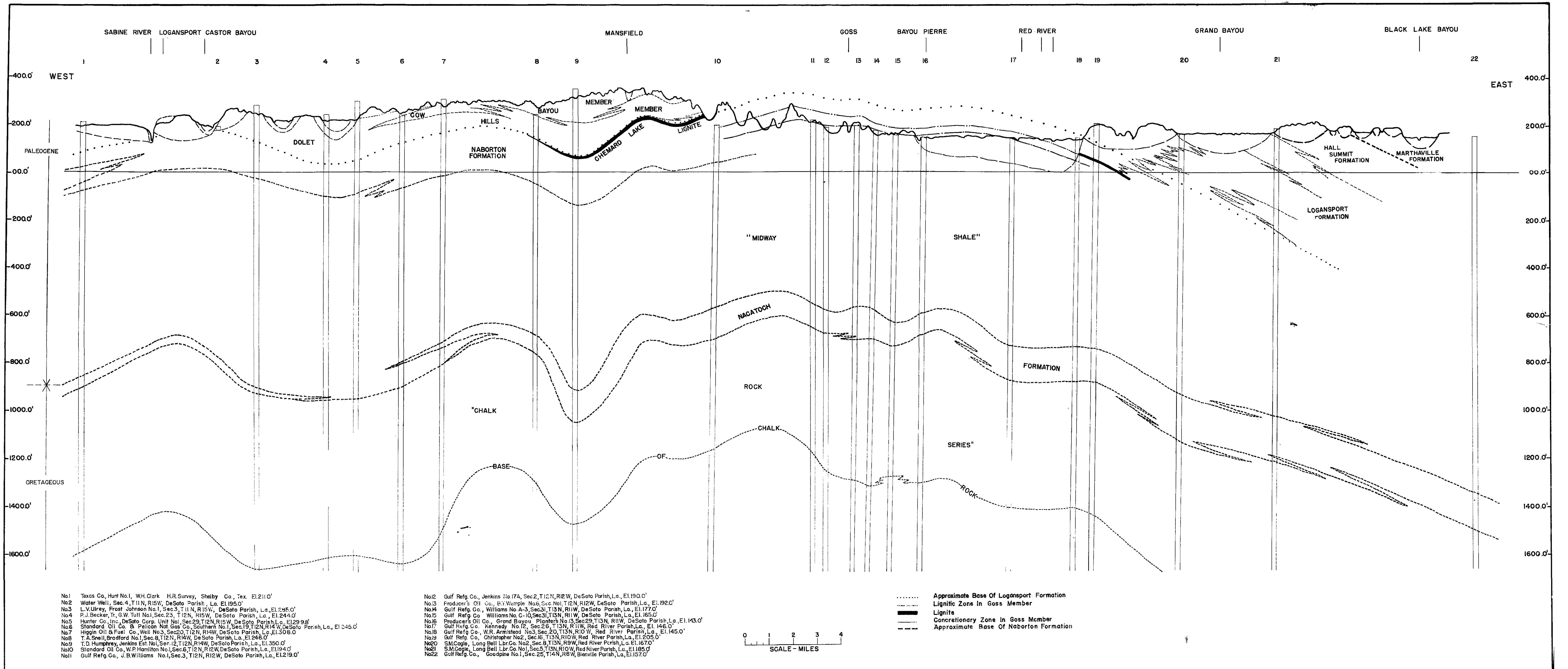


FIGURE 14. EAST - WEST CROSS SECTION SHOWING RELATIONSHIPS BETWEEN SURFACE AND SUBSURFACE SEDIMENTS, DESOTO AND RED RIVER PARISHES

No.1 Texas Co., Hunt No.1, W.H.Clark H.R.Survey, Shelby Co., Tex. El.211.0'
No.2 Water Well, Sec.4, T11N, R15W, DeSoto Parish, La. El.195.0'
No.3 L.V.Ulrey, Frost Johnson No.1, Sec.3, T11N, R15W, DeSoto Parish, La., El.285.0'
No.4 P.J.Becker, Tr., G.W. Tull No.1, Sec.23, T12N, R15W, DeSoto Parish, La., El.244.0'
No.5 Hunter Co., Inc., DeSoto Corp. Unit No1, Sec.29, T12N, R15W, DeSoto Parish, La., El.299.8'
No.6 Standard Oil Co. & Pelican Nat. Gas Co., Southern No.1, Sec.19, T12N, R14W, DeSoto Parish, La., El 245.0'
No.7 Higgin Oil & Fuel Co., Well No.3, Sec.20, T12N, R14W, DeSoto Parish, La., El.308.0
No.8 T.A.Snell, Bradford No.1, Sec.8, T12N, R14W, DeSoto Parish, La., El.246.0'
No.9 T.D. Humphrey, Jenkins Est. No1, Sec.12, T12N, R14W, DeSoto Parish, La., El.350.0'
No.10 Standard Oil Co., W.P. Hamilton No.1, Sec.6, T12N, R12W, DeSoto Parish, La., El.194.0'
No.11 Gulf Refg. Co., J.B.Williams No.1, Sec.3, T12N, R12W, DeSoto Parish, La., El.219.0'
No.12 Gulf Refg. Co., Jenkins No.17A, Sec.2, T12N, R12W, DeSoto Parish, La., El.190.0'
No.13 Producer's Oil Co., B.T.Wemple No.8, Sec.No1, T12N, R12W, DeSoto Parish, La., El.192.0'
No.14 Gulf Refg. Co., Williams No. A-3, Sec.31, T13N, R11W, DeSoto Parish, La., El.177.0'
No.15 Gulf Refg. Co Williams No. C-10, Sec.31, T13N, R11W, DeSoto Parish, La., El.165.0'
No.16 Producer's Oil Co., Grand Bayou Planter's No.13, Sec.29, T13N, R11W, DeSoto Parish, La., El.143.0'
No.17 Gulf Refg. Co. Kennedy No.12, Sec.26, T13N, R11W, Red River Parish, La., El. 146.0'
No.18 Gulf Refg. Co., W.R. Armistead No.3, Sec.20, T13N, R10W, Red River Parish, La., El.145.0'
No.19 Gulf Refg. Co., Christopher No.2, Sec.16, T13N, R10W, Red River Parish, La., El.205.0'
No20 S.M.Cagle, Long Bell Lbr.Co. No.2, Sec.8, T13N, R9W, Red River Parish, La. El.167.0'
No21 S.M.Cagle, Long Bell Lbr.Co. No1, Sec.5, T13N, R10W, Red River Parish, La., El.185.0'
No22 Gulf Refg. Co., Goodpine No.1, Sec.25, T14N, R8W, Bienville Parish, La., El.157.0'

0 1 2 3 4
SCALE - MILES

Approximate Base Of Logansport Formation
Lignitic Zone In Goss Member
Lignite
Concretionary Zone In Goss Member
Approximate Base Of Naborton Formation

FIGURE 14. EAST - WEST CROSS SECTION SHOWING RELATIONSHIPS BETWEEN SURFACE AND SUBSURFACE SEDIMENTS, DESOTO AND RED RIVER PARISHES

FIGURE 13. NORTH-SOUTH CROSS SECTION SHOWING RELATIONSHIPS OF SURFACE AND SUBSURFACE SEDIMENTS IN SOUTHERN DESOTO AND NORTHERN SABINE PARISHES, LA.

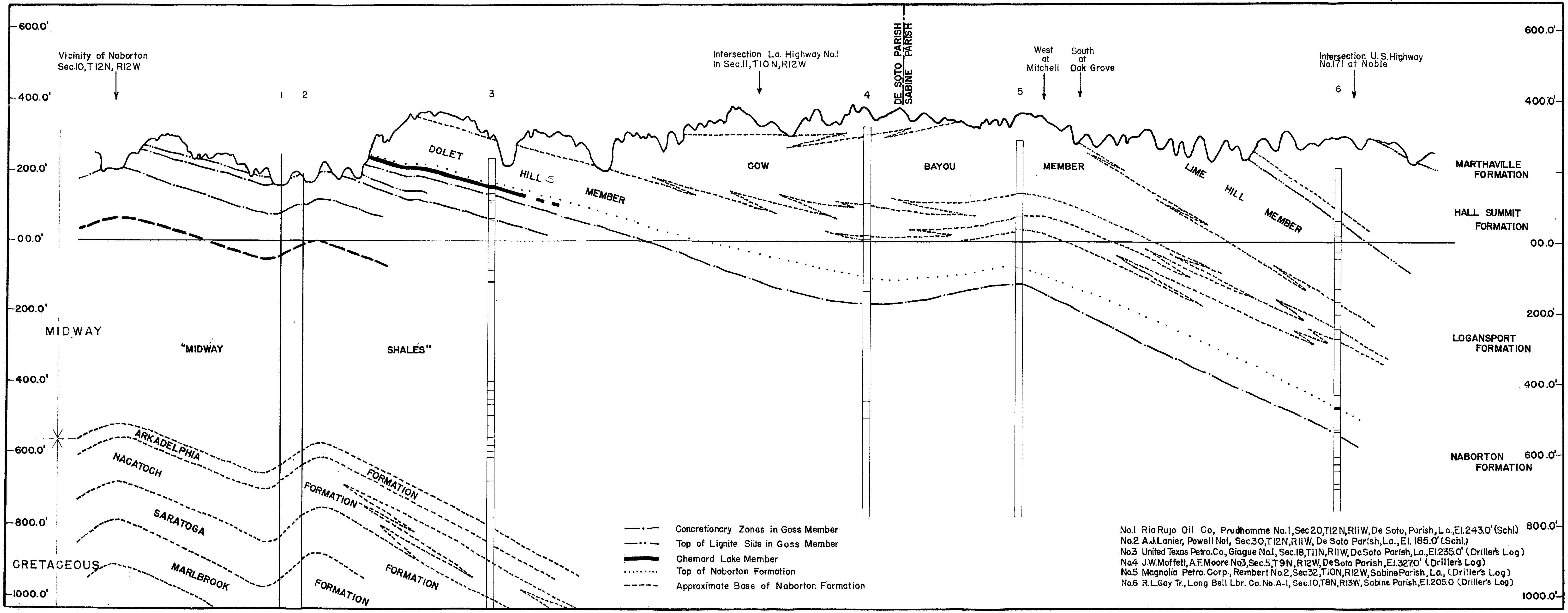
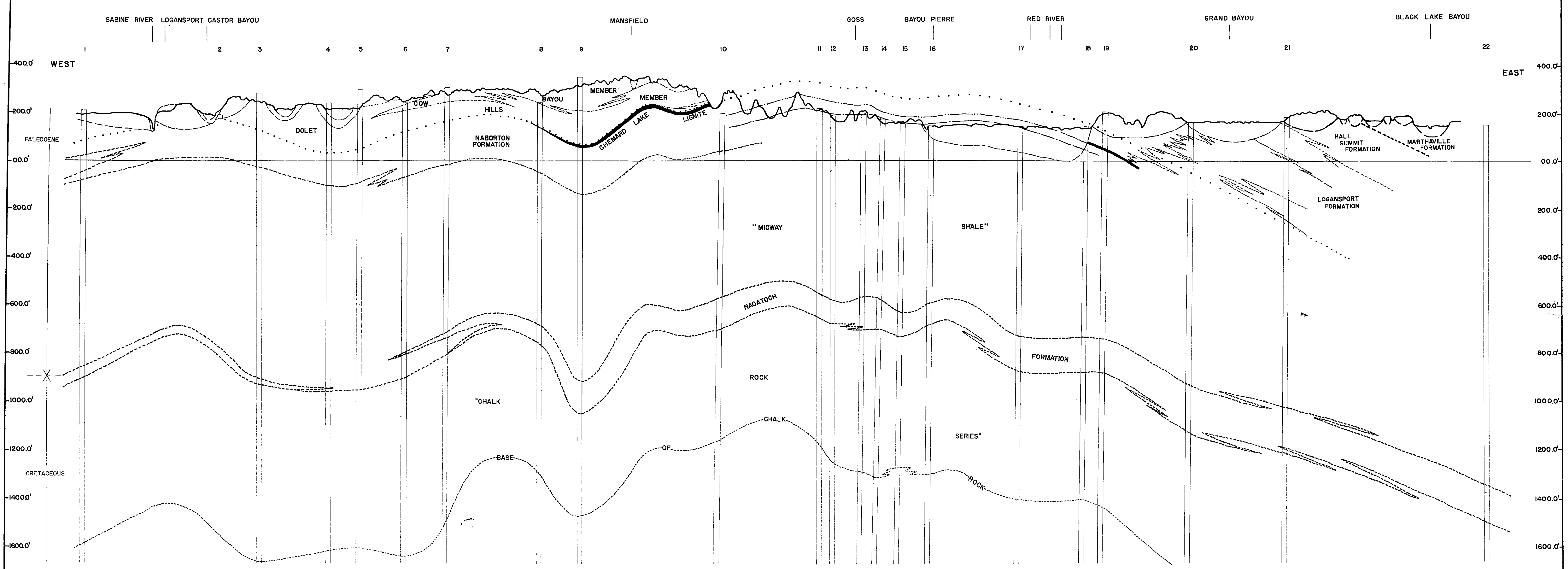


FIGURE 13. NORTH-SOUTH CROSS SECTION SHOWING RELATIONSHIPS OF SURFACE AND SUBSURFACE SEDIMENTS IN SOUTHERN DESOTO AND NORTHERN SABINE PARISHES, LA.

Fig 13



No.1 Texas Co., Hunt No.1, W.H.Clark H.R.Survey, Shelby Co., Tex. El.211.0'
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No.8 T.A.Snell, Bradford No.1, Sec.8, T12N, R14W, DeSoto Parish, La., El.246.0'
No.9 T.D. Humphrey, Jenkins Est. No1, Sec.12, T12N, R14W, DeSoto Parish, La., El.350.0'
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No.17 Gulf Refg. Co. Kennedy No.12, Sec.26, T13N, R11W, Red River Parish, La., El.146.0'
No.18 Gulf Refg. Co., W.R. Armistead No.3, Sec.20, T13N, R10W, Red River Parish, La., El.145.0'
No.19 Gulf Refg. Co., Christopher No.2, Sec.16, T13N, R10W, Red River Parish, La., El.205.0'
No.20 S.M.Cagle, Long Bell Lbr.Co. No.2, Sec.8, T13N, R9W, Red River Parish, La. El.167.0'
No.21 S.M.Cagle, Long Bell Lbr.Co. No1, Sec.5, T13N, R10W, Red River Parish, La., El.185.0'
No.22 Gulf Refg. Co., Goodpine No.1, Sec.25, T14N, R8W, Bienville Parish, La., El.157.0'

0 1 2 3 4
SCALE – MILES

.... Approximate Base Of Logansport Formation
Lignitic Zone In Goss Member
Lignite
Concretionary Zone In Goss Member
Approximate Base Of Naborton Formation

FIGURE 14. EAST – WEST CROSS SECTION SHOWING RELATIONSHIPS BETWEEN SURFACE AND SUBSURFACE SEDIMENTS, DESOTO AND RED RIVER PARISHES

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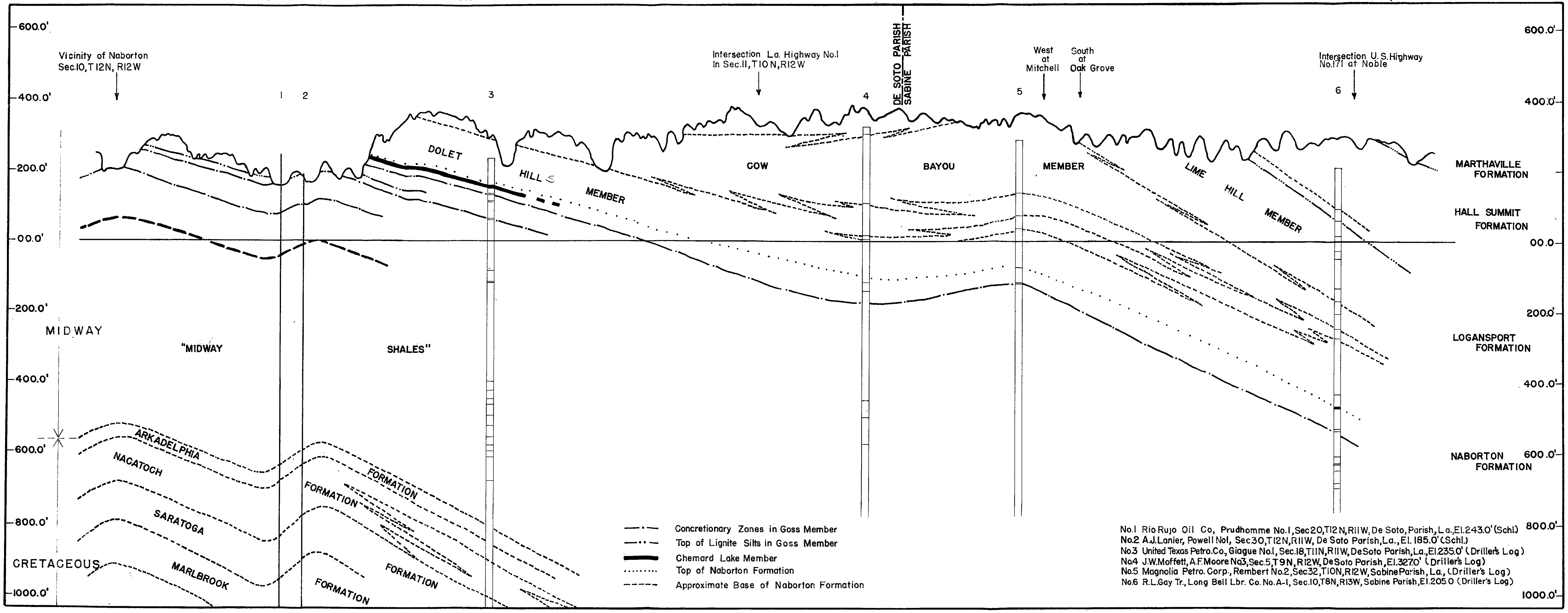


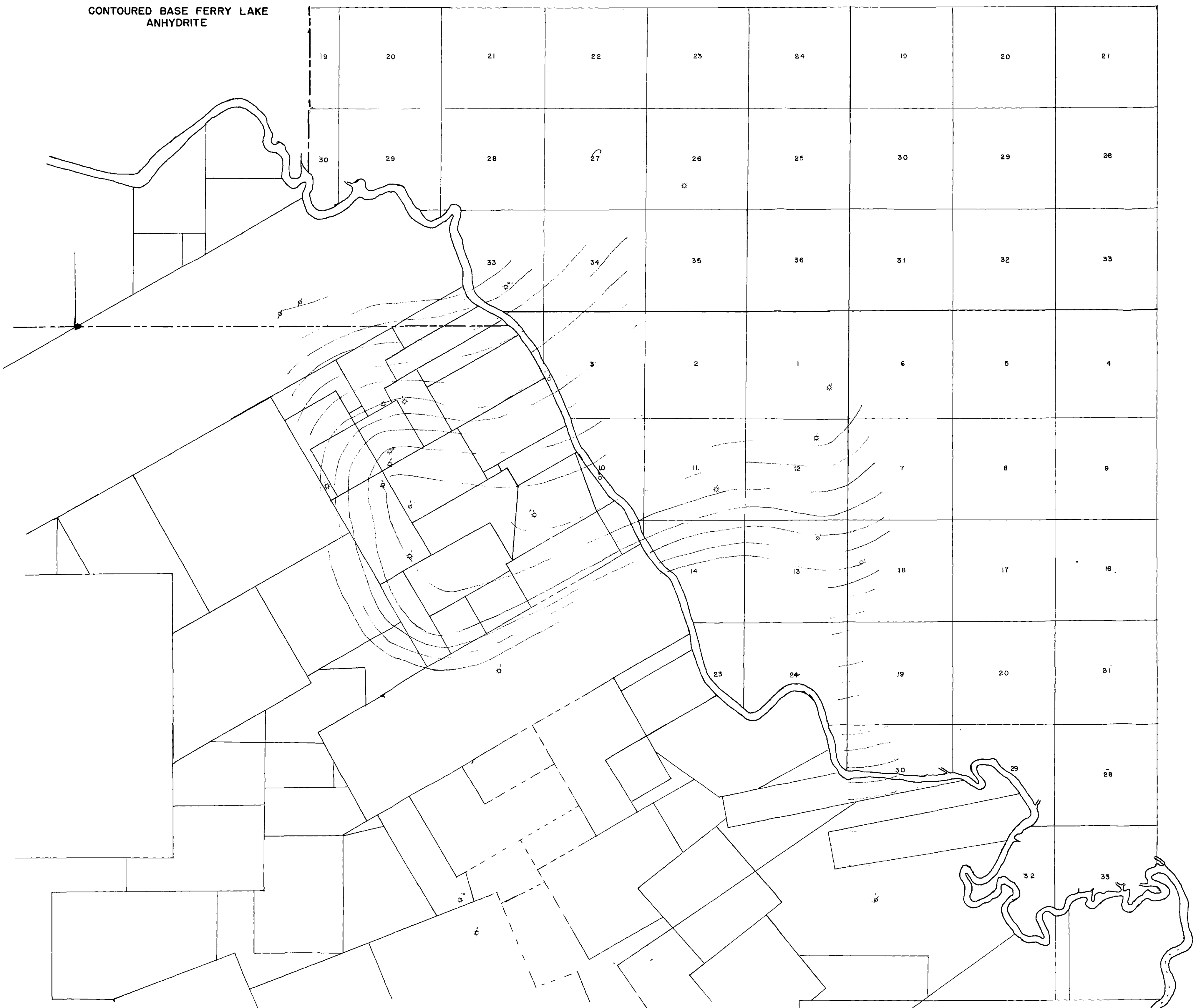
FIGURE 13. NORTH-SOUTH CROSS SECTION SHOWING RELATIONSHIPS OF SURFACE AND SUBSURFACE SEDIMENTS IN SOUTHERN DESOTO AND NORTHERN SABINE PARISHES, LA.

Fig 13

PLATE IX

LOGANSPORT FIELD

DE SOTO PH., LA., PANOLA CO.
AND SHELBY CO. TEXAS



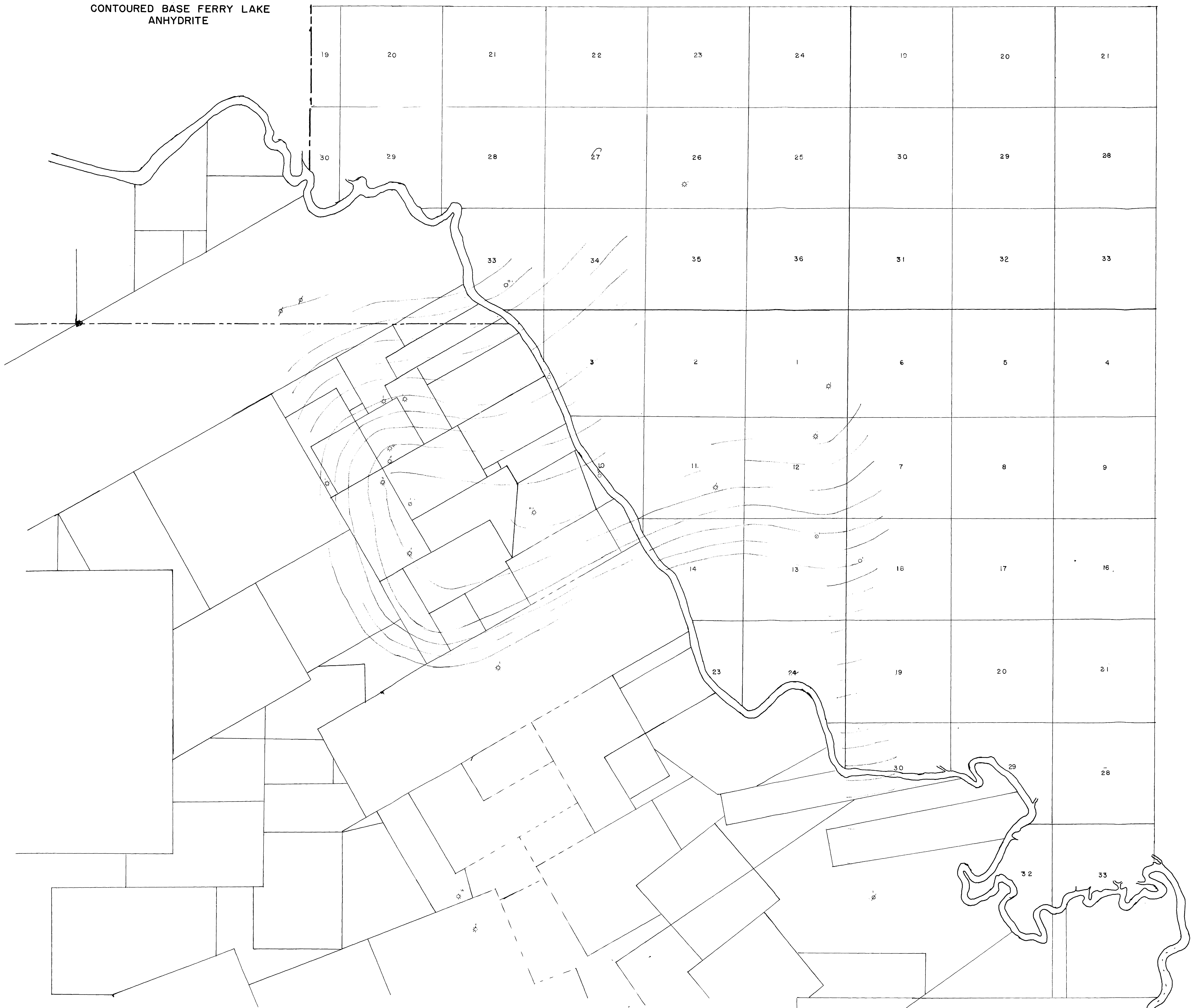
Contour Interval— 10 feet
Hor. Scale: 2 inches=1 mile

PLATE IX

LOGANSPORT FIELD

DE SOTO PH., LA., PANOLA CO.
AND SHELBY CO. TEXAS

CONTOURED BASE FERRY LAKE
ANHYDRITE



Contour Interval— 10 feet
Hor. Scale: 2 inches = 1 mile

PLATE VIII – STRUCTURAL MAP OF DESOTO-RED RIVER-BULL BAYOU OIL AND GAS FIELD (CONTOURS ON BASE OF OZAN CHALK, DEPTHS BELOW SEA LEVEL)

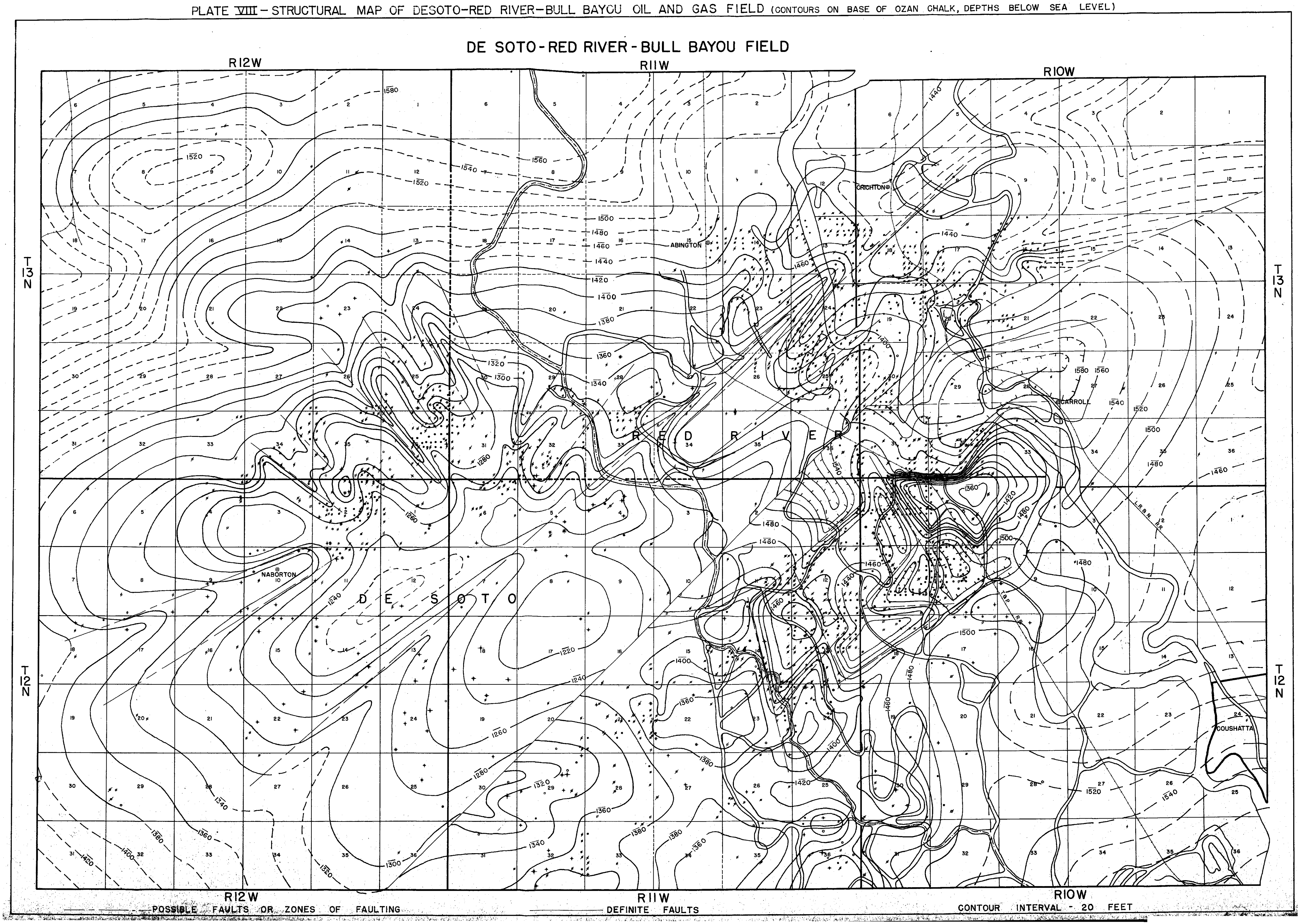
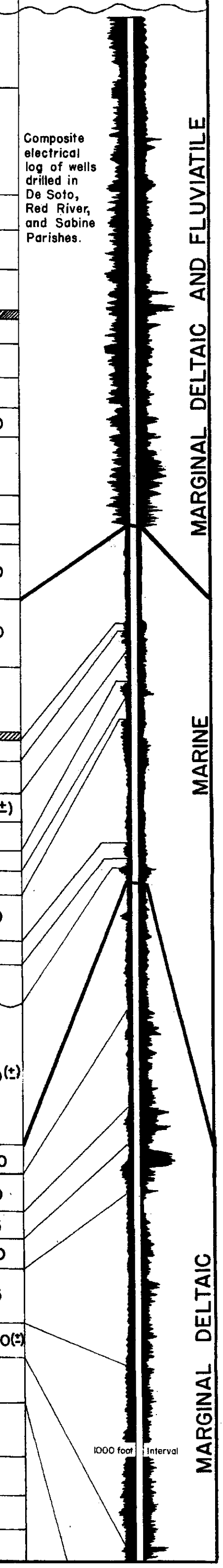


PLATE VIII - STRUCTURAL MAP OF DESOTO-RED RIVER-BULL BAYOU OIL AND GAS FIELD (CONTOURS ON BASE OF OZAN CHALK, DEPTHS BELOW SEA LEVEL)

PLATE — V

STRATIGRAPHIC COLUMN FOR DE SOTO AND RED RIVER PARISHES, LOUISIANA

REGIONAL USAGE				LOCAL USAGE				(5)	(5)	
SYSTEM	SERIES	GROUP	FORMATION	MEMBER	FACIES	Local Mapping Units and Faunal Zones	Deltaic and Fluviatile versus Marine (shaded) Sediments[1]	General Lithology	Average Thickness (feet)	STAGES OF DEPOSITION (LITHOLOGY)
QUATERNARY	RECENT	RECENT	Recent	Alluvium				clays silts sands gravels		FLUVIATILE
	PLEISTOCENE		Prairie			Criteria for Mapping: Elevation Drainage Pattern Height interval above floodplain Position Gravels $CaCO_3$ clays Sands, etc. Silicified wood		clays silts sands gravels		FLUVIATILE
			Montgomery					clays silts sands gravels		FLUVIATILE
			Bentley					clays silts sands gravels		FLUVIATILE
			Williana							FLUVIATILE
TERTIARY	EOCENE	SABINE "WILCOX"	Sabinetown[2] (restricted) (Not present in DeSoto and Red River Parishes)					Locally calcareous clays, silts, and sands. glauconite		
			Pendleton[2] (Not present in DeSoto and Red River Parishes)					Locally calcareous clays, silts, and sands. glauconite		
			Marthaville[4]			Calcareous concretions			100	
						Lignitic shales Ferruginous concretions			50	
						Fossils, calcareous concretions, sands. Ostrea thirsae			100	
	PALEOCENE	MIDWAY	Hall Summit	Bisteneau		Calcareous concretions Glauconite			100	
				Grand Bayou		Lignitic shales, ferruginous concretions Glauconite			75	
				Loggy Bayou		Sands Ferruginous concretions			50	
			Logansport	Lime Hill		Calcareous concretions, fossils, soils Silicified wood, vegetation			200	
				Cow Bayou	Lula Benson	Lignitic shales, silicified wood Fossil leaves, ferruginous concretions Soils, vegetation			90	
				Dolet Hills		Sands			50	
			Naborton	Chemard Lake lentil		Lignite			5	
						Calcareous concretions, buff-colored sediments, lignite, ferruginous concretions fossil leaves, soils, and vegetation			200	
			Lignitic clays and silts with Wills Point microfauna.						500	
			Kincaid						30	
CRETACEOUS	GULF[6]	NAVARRO	Arkadelphia						50	
			Nacatoch						150	
			Saratoga						50(±)	
		TAYLOR	Marlbrook (restricted)						150	
			Annona						125	
			Ozan	OZAN CHALK BUCKRANGE SAND					140	
		AUSTIN	Brownstown (restricted)							
			Tokio						750	
			Ector Tongue (Austin chalk)						110	
		EAGLE FORD	Eagle Ford						110	
	COMANCHE[3]	WASHITA	(Undifferentiated)						0-250(±)	
		FREDERICKS-BURG	(Undifferentiated)							
		TRINITY	Paluxy						1200	
			Mooringsport						750	
			Ferry Lake						235	
			Rodessa						350	
			Pine Island						825	
			Sligo							
		COAHUILA	Hosston						2000(±)	
JURASSIC[3] (UPPER)			Cotton Valley							
			Buckner							
			Smackover							
			Eagle Mills					Salt and Red shales		
			~~Morehouse~~					Dark shales and limy sediments		



(1) Designed to show relative amounts of deltaic and fluviatile sediments in contrast to marine sediments.

(2) Faunal unit.

(3) Formational names after Imlay (1940); used by Shreveport Geological Society.

(4) Carries a Nanafalia (basal Sabine of Alabama) fauna.

(5) Based on a study of electrical logs plus some Paleontology.

(6) Formational names after Shreveport Geological Society (1939).

LEGEND

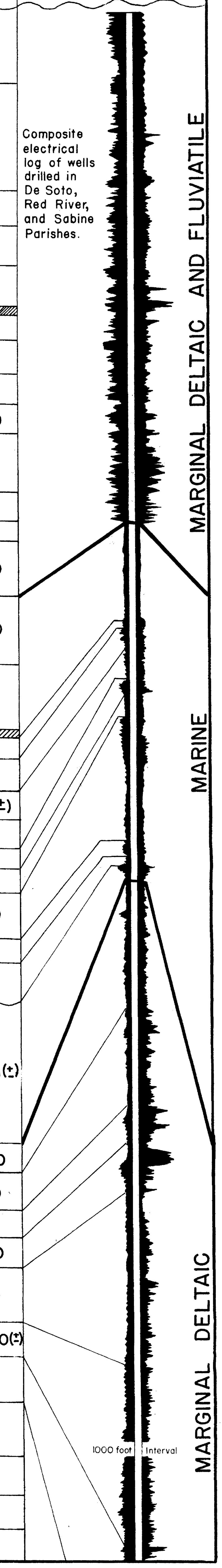
Shale or clay	Anhydrite
Sand	Red beds
Limestone	Lignite
Chalk	Calcareous concretions
Marl	Glauconite

PLATE — V

STRATIGRAPHIC COLUMN FOR DE SOTO AND RED RIVER PARISHES, LOUISIANA

REGIONAL USAGE: SYSTEM	SERIES	GROUP	FORMATION	LOCAL USAGE: MEMBER	FACIES	Local Mapping Units and Faunal Zones	(5) General Lithology	(5) Average Thickness (feet)	STAGES OF DEPOSITION (LITHOLOGY)
QUATERNARY	RECENT	RECENT	Recent	Alluvium			clays silts sands gravels		FLUVIATILE
QUATERNARY	PLEISTOCENE		Prairie			Criteria for Mapping: Elevation; Drainage Pattern; Height interval above floodplain; Position; Gravels; $CaCO_3$ clays; Sands, etc.; Silicified wood	clays silts sands gravels		FLUVIATILE
			Montgomery				clays silts sands gravels		FLUVIATILE
			Bentley				clays silts sands gravels		FLUVIATILE
			Williana						FLUVIATILE
TERTIARY	EOCENE	SABINE "WILCOX"	Sabinetown[2] (restricted) (Not present in DeSoto and Red River Parishes)				Locally calcareous clays, silts, and sands. glauconite		MARGINAL DELTAIC AND FLUVIATILE
			Pendleton[2] (Not present in DeSoto and Red River Parishes)				Locally calcareous clays, silts, and sands. glauconite		
			Marthaville[4]			Calcareous concretions		100	
						Lignitic shales; Ferruginous concretions		50	
						Fossils, calcareous concretions, sands. Ostrea thirsae		100	
	PALEOCENE	MIDWAY	Hall Summit	Bisteneau		Calcareous concretions; Glauconite		100	
				Grand Bayou		Lignitic shales, ferruginous concretions; Glauconite		75	
				Loggy Bayou		Sands; Ferruginous concretions		50	
			Logansport	Lime Hill		Calcareous concretions, fossils, soils; Silicified wood, vegetation		200	
				Cow Bayou	Lula; Benson	Lignitic shales, silicified wood; Fossil leaves, ferruginous concretions; Soils, vegetation		90	
				Dolet Hills		Sands		50	
				Chemard Lake lentil		Lignite		5	
			Naborton			Calcareous concretions, buff-colored sediments, lignite, ferruginous concretions fossil leaves, soils, and vegetation		200	
			Lignitic clays and silts with Wills Point microfauna.					500	MARINE
			Kincaid					30	
CRETACEOUS	GULF[6]	NAVARRO	Arkadelphia					50	
			Nacatoch					150	
			Saratoga					50(±)	
		TAYLOR	Marlbrook (restricted)					150	
			Annona					125	
			Ozan	OZAN CHALK; BUCKRANGE SAND				140	
		AUSTIN	Brownstown (restricted)						
			Tokio					750	
			Ector Tongue (Austin chalk)					110	
		EAGLE FORD	Eagle Ford					110	
	COMANCHE[3]	WASHITA	(Undifferentiated)					0-250(±)	
		FREDERICKS-BURG	(Undifferentiated)						
		TRINITY	Paluxy					1200	MARGINAL DELTAIC
			Mooringsport					750	
			Ferry Lake					235	
			Rodessa					350	
			Pine Island					825	
			Sligo						
		COAHUILA	Hosston					2000(±)	
JURASSIC[3] (UPPER)			Cotton Valley						
			Buckner						
			Smackover						
			Eagle Mills				Salt and Red shales		
			~~Morehouse~~				Dark shales and limy sediments		

Deltaic and Fluviatile versus Marine (shaded) Sediments[1]



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LEGEND

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- Sand
- Limestone
- Chalk
- Marl
- Anhydrite
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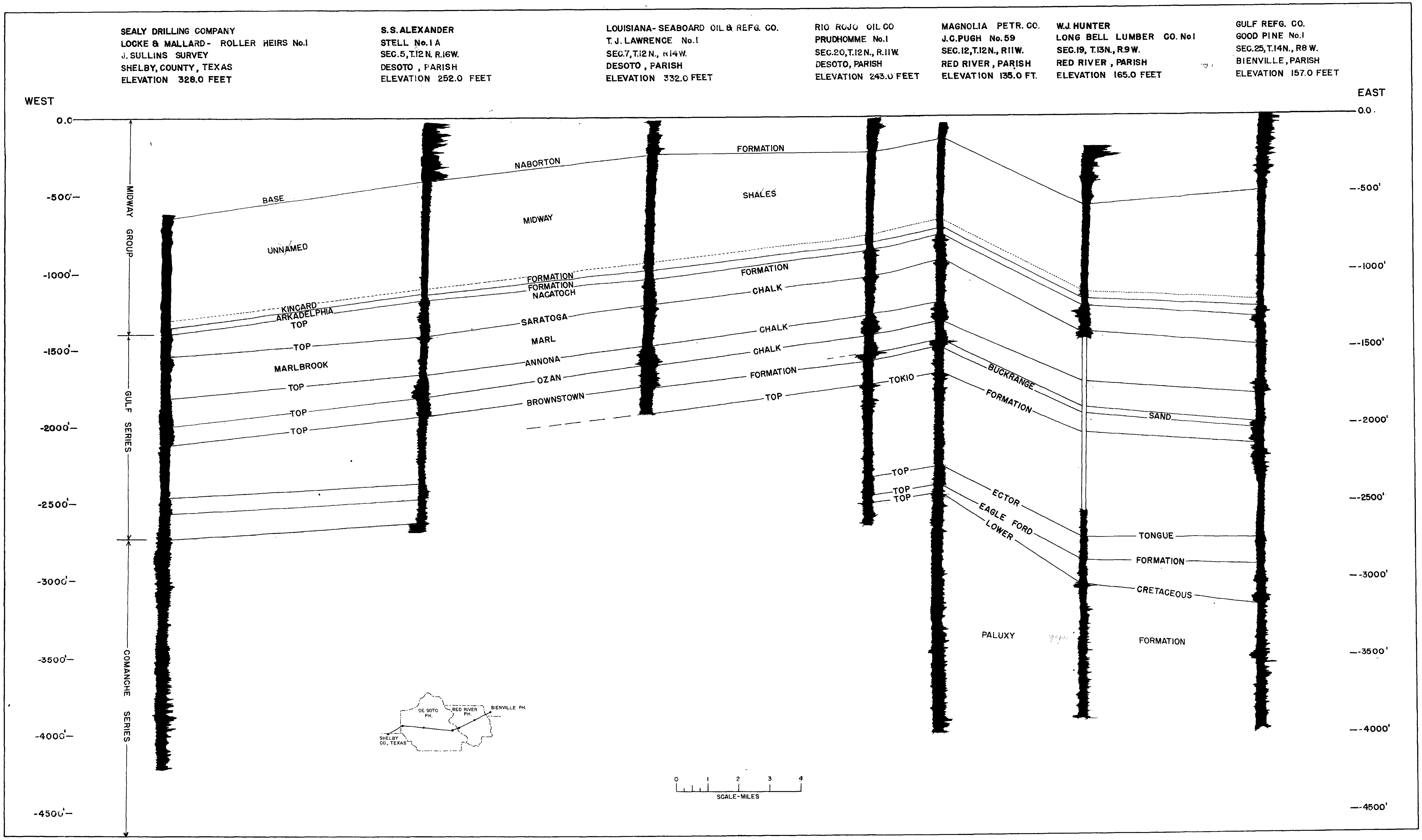
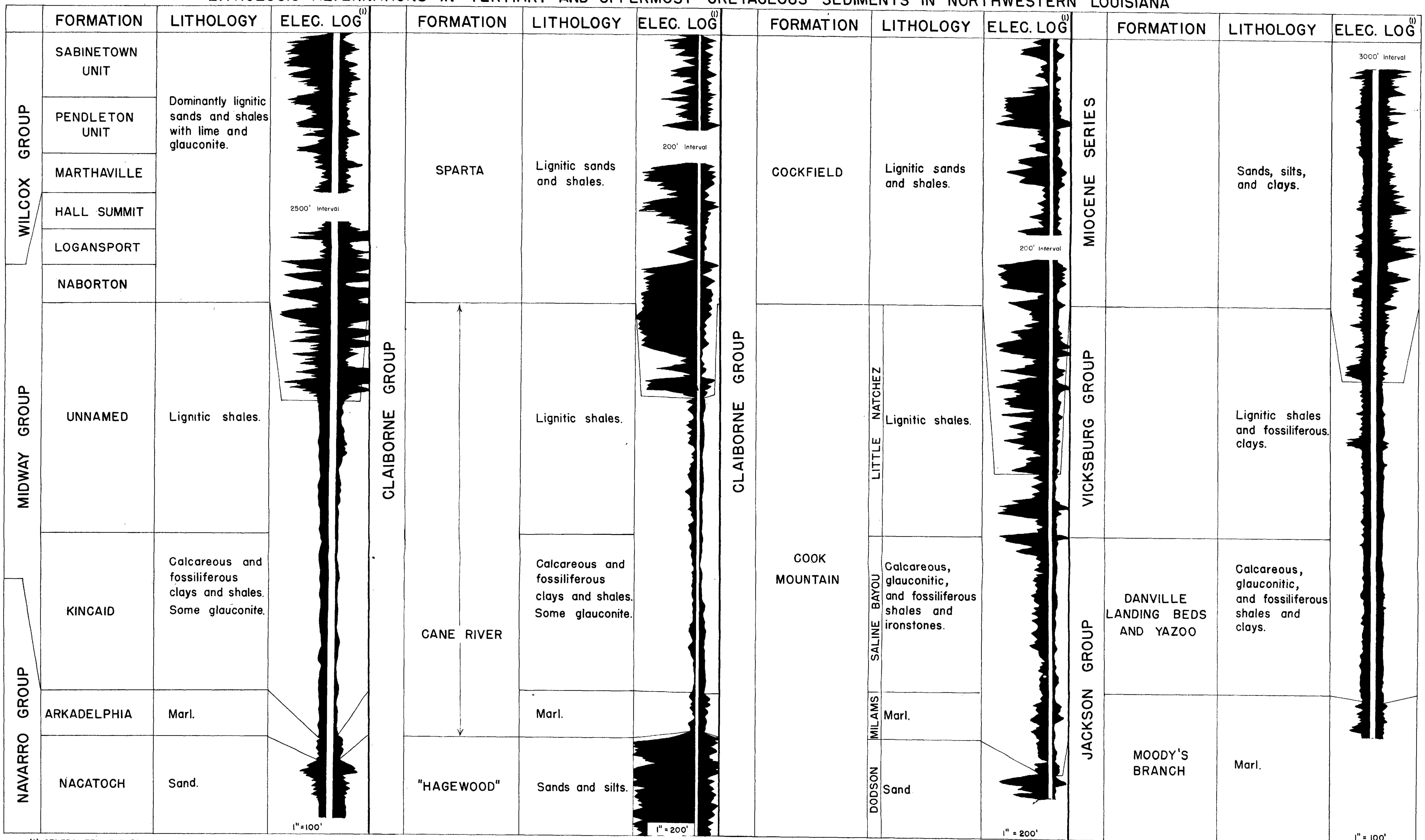


FIGURE 8. EAST-WEST ELECTRICAL LOG SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

FIGURE 8. EAST-WEST ELECTRICAL LOG SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

FIGURE 11 -
LITHOLOGIC ALTERNATIONS IN TERTIARY AND UPPERMOST CRETACEOUS SEDIMENTS IN NORTHWESTERN LOUISIANA



(1) GENERALIZED ELECTRICAL LOGS FROM DE SOTO, RED RIVER, SABINE, NATCHITOCHES, AND RAPIDES PARISHES, LOUISIANA.

FIGURE 11 - LITHOLOGIC ALTERNATIONS IN TERTIARY AND UPPERMOST CRETACEOUS SEDIMENTS IN NORTHWESTERN LOUISIANA

(1) GENERALIZED ELECTRICAL LOGS FROM DE SOTO, RED RIVER, SABINE, NATCHITOCHES, AND RAPIDES PARISHES, LOUISIANA.

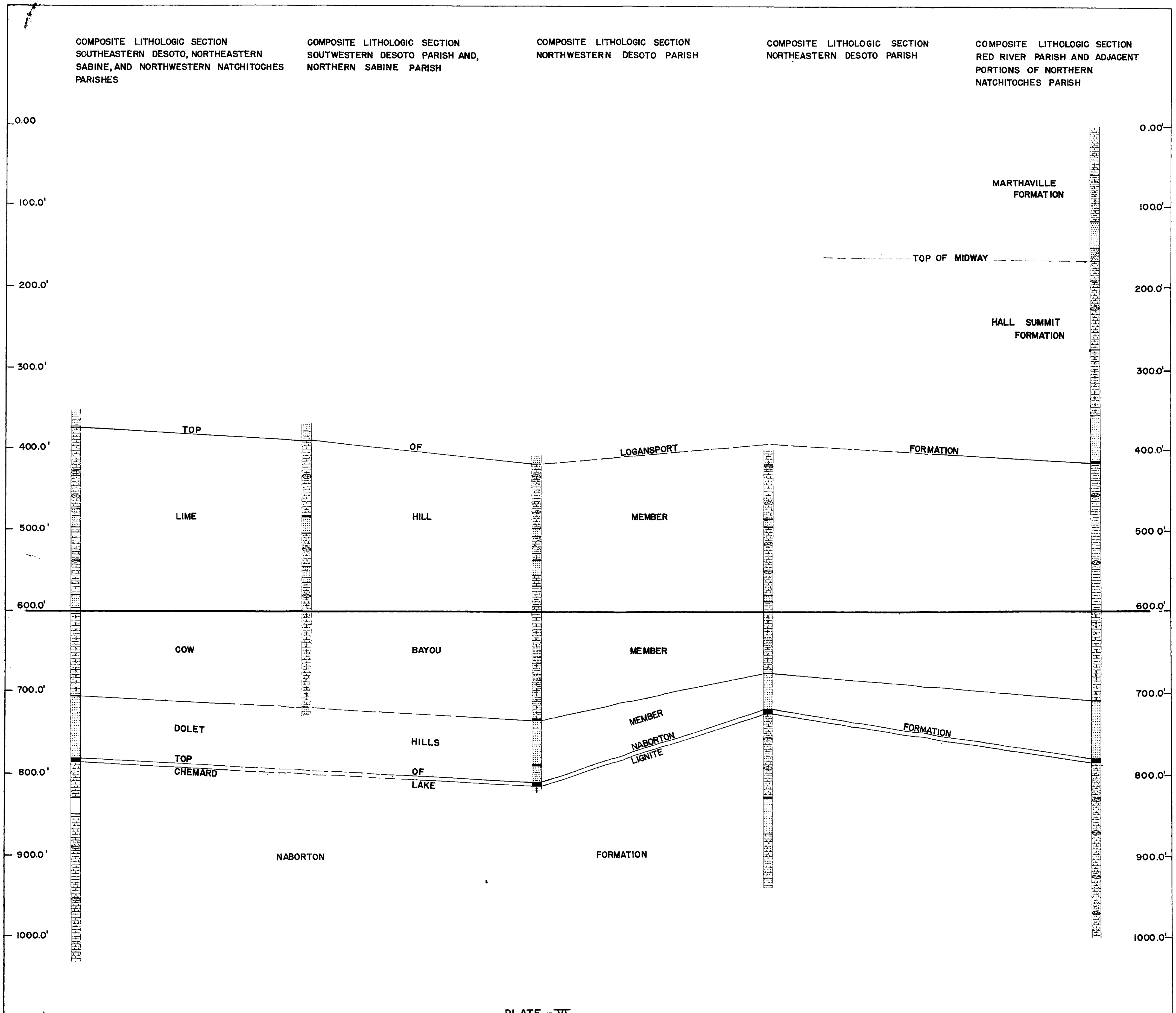


PLATE - VI
GENERALIZED COMPOSITE LITHOLOGIC SECTIONS SHOWING RELATIVE THICKNESSES OF MIDWAY AND WILCOX IN DESOTO AND RED RIVER PARISHES, LOUISIANA

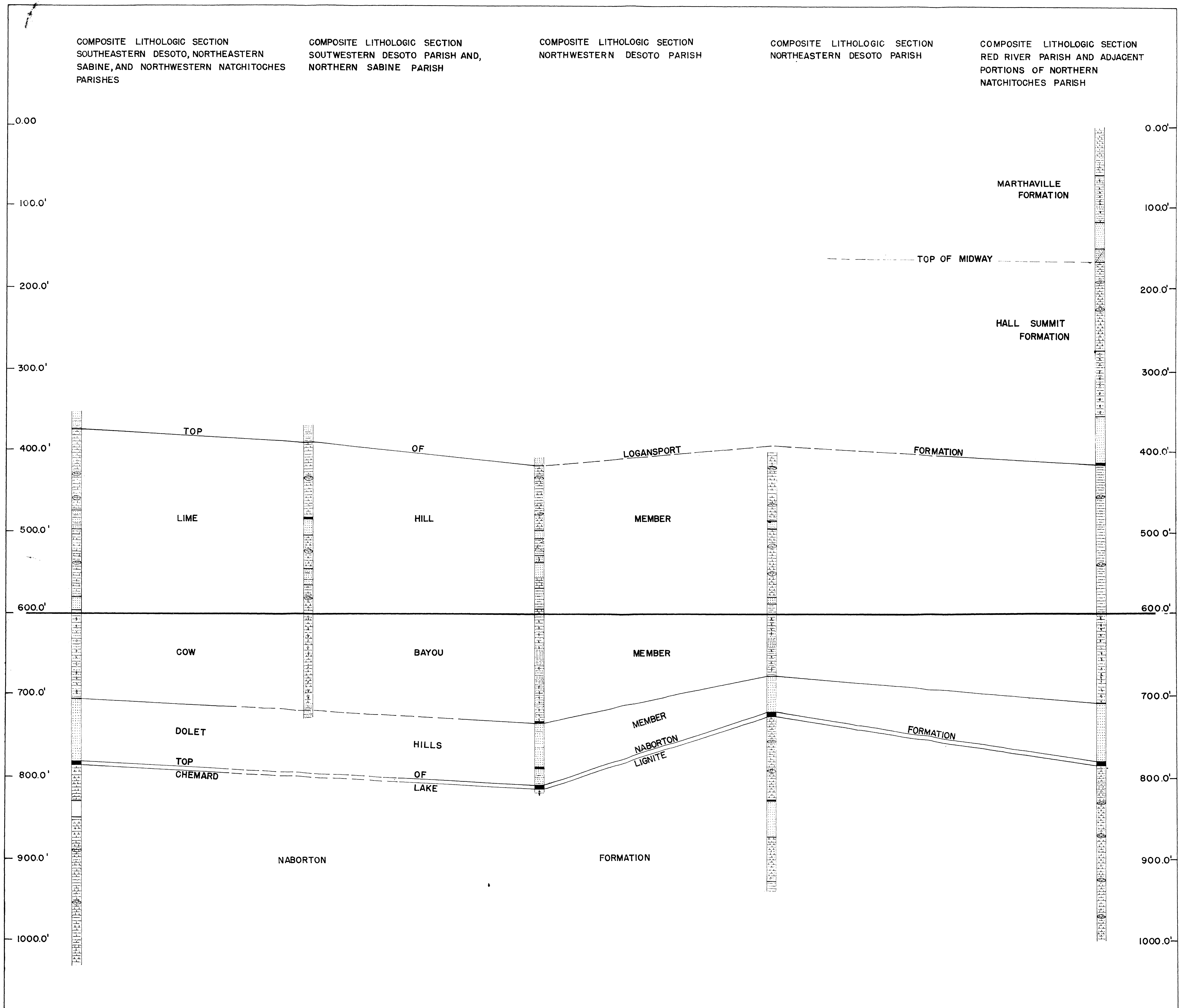


PLATE – VI

GENERALIZED COMPOSITE LITHOLOGIC SECTIONS SHOWING RELATIVE THICKNESSES OF MIDWAY AND WILCOX IN DESOTO AND RED RIVER PARISHES, LOUISIANA

VI

Figure 5. Cross section showing Recent alluvial deposits and surfaces of Red River at Coushatta, Red River Parish.

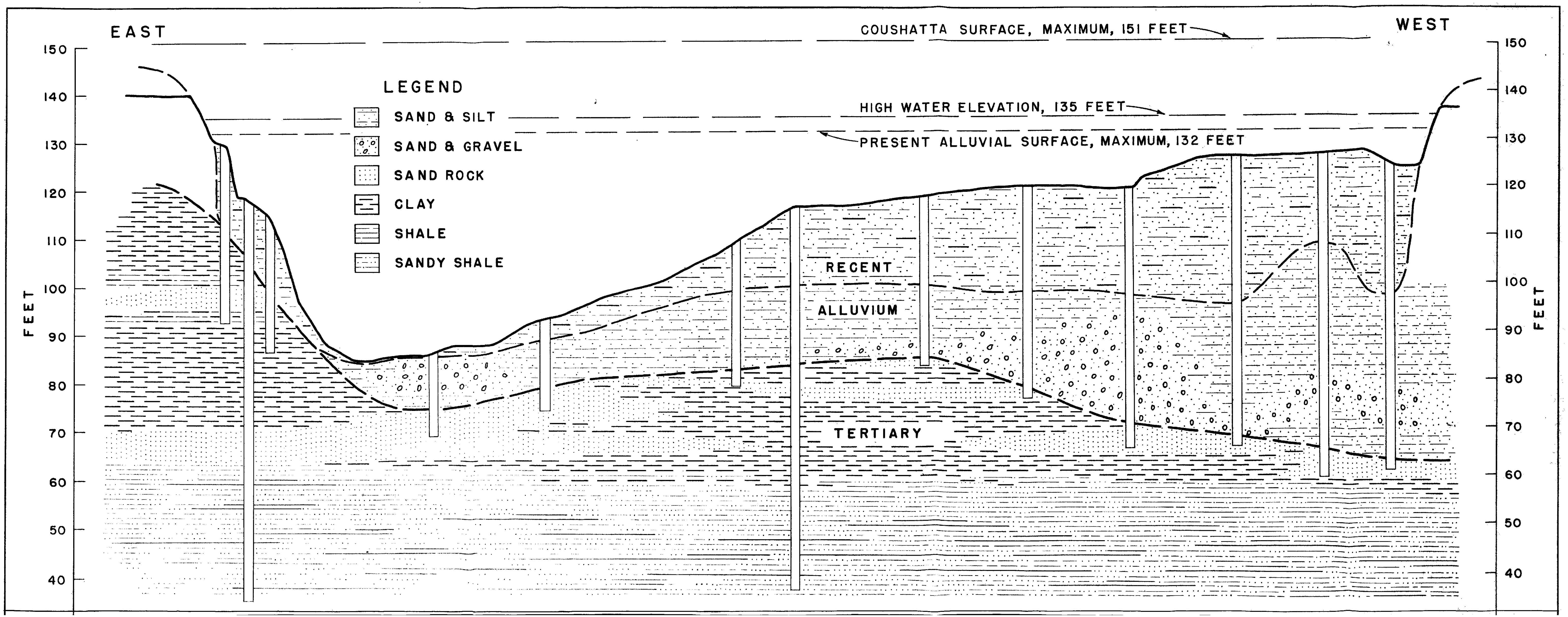
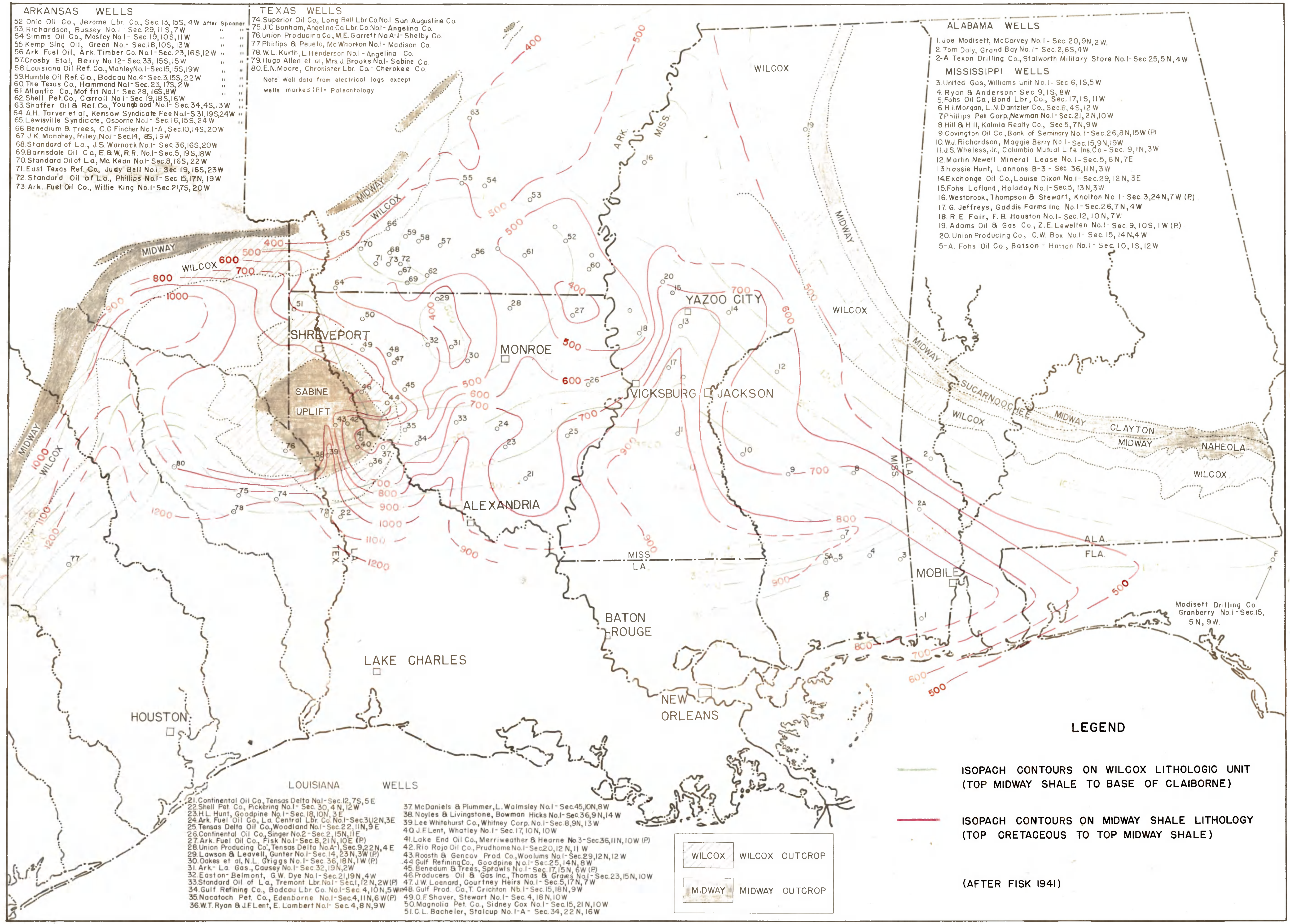


Figure 5. Cross section showing Recent alluvial deposits and surfaces of Red River at Coushatta, Red River Parish.

Fig 5



ARKANSAS WELLS
52. Ohio Oil Co., Jerome Lbr. Co., Sec. 13, 15S, 4W After Spooner
53. Richardson, Bussey No. 1 - Sec. 29, 11 S, 7 W "
54. Simms Oil Co., Mosley No. 1 - Sec. 19, 10S, 11 W "
55. Kemp Sing Oil, Green No. - Sec. 18, 10S, 13 W "
56. Ark. Fuel Oil, Ark. Timber Co. No. 1 - Sec. 23, 16S, 12 W "
57. Crosby Etal, Berry No. 12 - Sec. 33, 15S, 15 W "
58. Louisiana Oil Ref. Co., Manley No. 1 - Sec. 15, 15S, 19W "
59. Humble Oil Ref. Co., Bodcau No. 4 - Sec. 3, 15S, 22 W "
60. The Texas Co., Hammond No. 1 - Sec. 23, 17S, 2 W "
61. Atlantic Co., Mof fit No. 1 - Sec. 28, 16S, 8W "
62. Shell Pet. Co., Carroll No. 1 - Sec. 19, 18 S, 16W "
63. Shaffer Oil & Ref. Co., Youngblood No. 1 - Sec. 34, 4S, 13 W "
64. A.H. Tarver et al, Kensaw Syndicate Fee No. 1 - S. 31, 19S, 24W "
65. Lewisville Syndicate, Osborne No. 1 - Sec. 16, 15S, 24 W "
66. Benedium & Trees, C.C. Fincher No. 1 - A., Sec. 10, 14S, 20W
67. J.K. Mohohey, Riley No. 1 - Sec. 14, 18S, 19W
68. Standard of La., J.S. Warnock No. 1 - Sec. 36, 16S, 20W
69. Barnsdale Oil Co., E. & W., R.R. No. 1 - Sec. 5, 19S, 18W
70. Standard Oil of La., Mc. Kean No. 1 - Sec. 8, 16S, 22 W
71. East Texas Ref. Co., Judy Bell No. 1 - Sec. 19, 16S, 23W
72. Standard Oil of La., Phillips No. 1 - Sec. 15, 17N, 19 W
73. Ark. Fuel Oil Co., Willie King No. 1 - Sec. 21, 7S, 20 W
TEXAS WELLS
74. Superior Oil Co., Long Bell Lbr. Co. No. 1 - San Augustine Co.
75. J.C. Bonham, Angelina Co. Lbr. Co. No. 1 - Angelina Co.
76. Union Producing Co., M.E. Garrett No. A-1 - Shelby Co.
77. Phillips & Peueto, Mc Whorton No. 1 - Madison Co.
78. W.L. Kurth, L. Henderson No. 1 - Angelina Co.
79. Hugo Allen et al, Mrs. J. Brooks No. 1 - Sabine Co.
80. E.N. Moore, Chronister Lbr. Co. - Cherokee Co.
Note: Well data from electrical logs except wells marked (P) = Paleontology
ALABAMA WELLS
1. Joe Modisett, McCorvey No. 1 - Sec. 20, 9N, 2 W.
2. Tom Daly, Grand Bay No. 1 - Sec. 2, 6S, 4W
2-A. Texon Drilling Co., Stalworth Military Store No. 1 - Sec. 25, 5 N, 4 W
MISSISSIPPI WELLS
3. United Gas, Williams Unit No. 1 - Sec. 6, 1S, 5 W
4. Ryan & Anderson - Sec. 9, 1S, 8W
5. Fohs Oil Co., Bond Lbr., Co., Sec. 17, 1S, 11 W
6. H.I. Morgan, L.N. Dantzler Co., Sec. 8, 4S, 12 W
7. Phillips Pet. Corp., Newman No. 1 - Sec. 21, 2 N, 10 W
8. Hill & Hill, Kalmia Realty Co., Sec. 5, 7N, 9 W
9. Covington Oil Co., Bank of Seminary No. 1 - Sec. 26, 8N, 15W (P)
10. W.J. Richardson, Maggie Berry No. 1 - Sec. 15, 9N, 19W
11. J.S. Wheless, Jr., Columbia Mutual Life Ins. Co. - Sec. 19, 1N, 3W
12. Martin Newell Mineral Lease No. 1 - Sec. 5, 6 N, 7E
13. Hossie Hunt, Lannons B-3 - Sec. 36, 11N, 3W
14. Exchange Oil Co., Louise Dixon No. 1 - Sec. 29, 12 N, 3E
15. Fohs Lofland, Holaday No. 1 - Sec. 5, 13N, 3W
16. Westbrook, Thompson & Stewart, Knolton No. 1 - Sec. 3, 24N, 7 W (P)
17. G. Jeffreys, Gaddis Farms Inc. No. 1 - Sec. 26, 7 N, 4 W
18. R.E. Fair, F.B. Houston No. 1 - Sec. 12, 10 N, 7 W
19. Adams Oil & Gas Co., Z.E. Lewellen No. 1 - Sec. 9, 10S, 1 W (P)
20. Union Producing Co., C.W. Box No. 1 - Sec. 15, 14 N, 4 W
5-A. Fohs Oil Co., Batson - Hatton No. 1 - Sec. 10, 1S, 12 W
LOUISIANA WELLS
21. Continental Oil Co., Tensas Delta No. 1 - Sec. 12, 7S, 5 E
22. Shell Pet. Co., Pickering No. 1 - Sec. 30, 4 N, 12 W
23. H.L. Hunt, Goodpine No. 1 - Sec. 18, 10N, 3 E
24. Ark. Fuel Oil Co., La. Central Lbr. Co. No. 1 - Sec. 31, 12 N, 3E
25. Tensas Delta Oil Co., Woodland No. 1 - Sec. 22, 11N, 9 E
26. Continental Oil Co., Singer No. 2 - Sec. 2, 15N, 11 E
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29. Lawson & Leavell, Gunter No. 1 - Sec. 14, 23 N, 3W (P)
30. Oakes et al, N.L. Griggs No. 1 - Sec. 36, 18 N, 1 W (P)
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33. Standard Oil of La., Tremont Lbr. No. 1 - Sec. 1, 12 N, 2W (P)
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35. Nacatoch Pet. Co., Edenborne No. 1 - Sec. 4, 11 N, 6 W (P)
36. W.T. Ryan & J.F. Lent, E. Lambert No. 1 - Sec. 4, 8 N, 9 W
37. McDaniels & Plummer, L. Walmsley No. 1 - Sec. 45, 10N, 8 W
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YAZOO CITY
VICKSBURG
JACKSON
ALEXANDRIA
BATON ROUGE
LAKE CHARLES
HOUSTON
NEW ORLEANS
MOBILE
SABINE UPLIFT
ARK. MISS.
MISS. LA.
TEX. LA.
ALA. FLA.
MISS. ALA.
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WILCOX
SUCARNOOCHEE
CLAYTON
NAHEOLA
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ISOPACH CONTOURS ON MIDWAY SHALE LITHOLOGY (TOP CRETACEOUS TO TOP MIDWAY SHALE)
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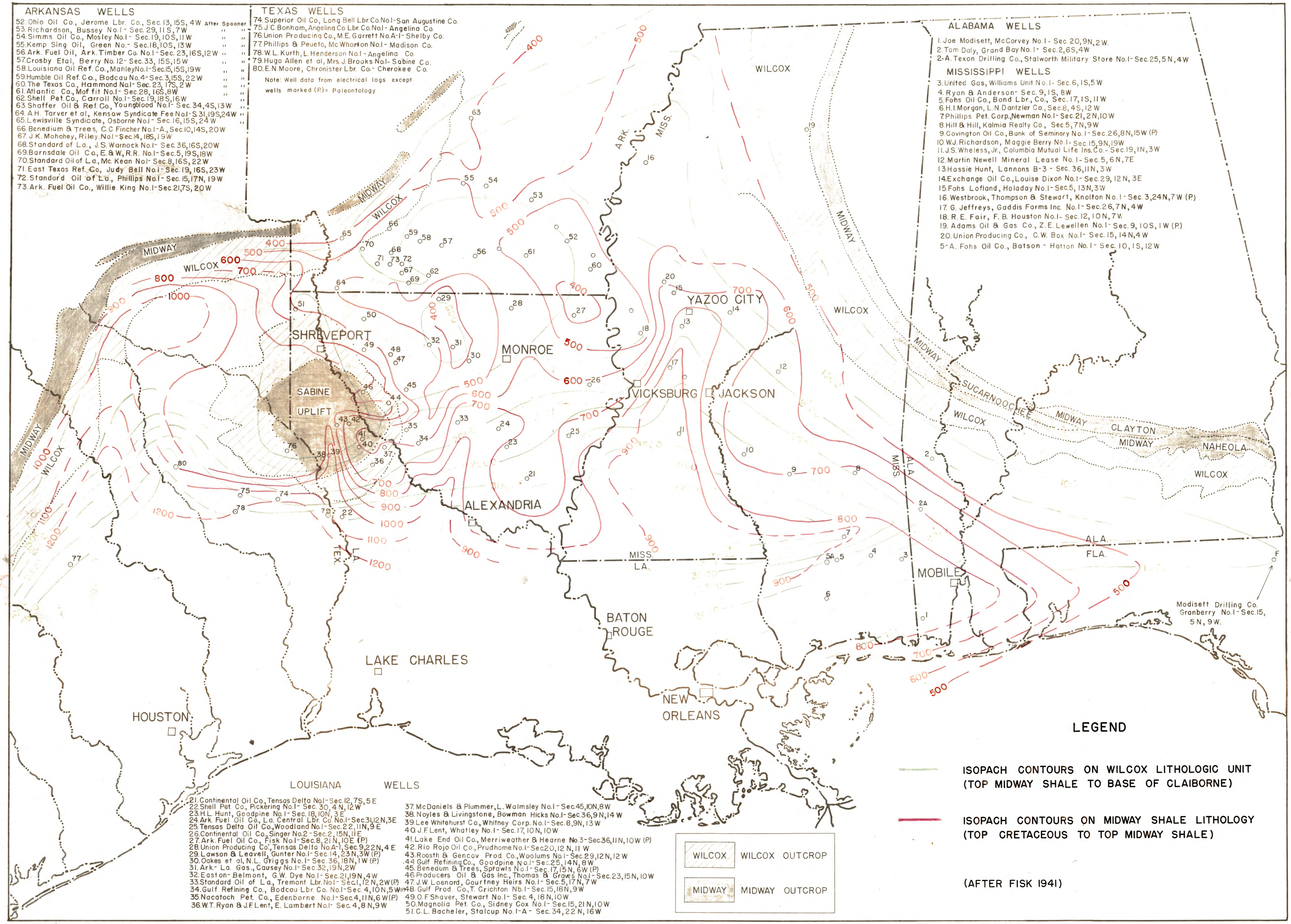

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26. Continental Oil Co., Singer No. 2 - Sec. 2, 15N, 11E
27. Ark. Fuel Oil Co., Fisk No. 1 - Sec. 8, 21N, 10E (P.)
28. Union Producing Co., Tensas Delta No. A-1, Sec. 9, 22N, 4E
29. Lawson & Leavell, Gunter No. 1 - Sec. 14, 23N, 3W (P.)
30. Oakes et al, N.L. Griggs No. 1 - Sec. 36, 18N, 1W (P.)
31. Ark.-La. Gas., Causey No. 1 - Sec. 32, 19N, 2W
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33. Standard Oil of La., Tremont Lbr. No. 1 - Sec. 1, 12N, 2W (P.)
34. Gulf Refining Co., Bodcau Lbr. Co. No. 1 - Sec. 4, 10N, 5W (P.)
35. Nacatoch Pet. Co., Edenborne No. 1 - Sec. 4, 11N, 6W (P.)
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45. Benedum & Trees, Sprawls No. 1 - Sec. 17, 15N, 6W (P.)
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LEGEND
ISOPACH CONTOURS ON WILCOX LITHOLOGIC UNIT (TOP MIDWAY SHALE TO BASE OF CLAIBORNE)
ISOPACH CONTOURS ON MIDWAY SHALE LITHOLOGY (TOP CRETACEOUS TO TOP MIDWAY SHALE)
WILCOX OUTCROP
MIDWAY OUTCROP
(AFTER FISK 1941)

	Louisiana Midway Localities (See Map and Appendix II)									Texas			Ala.			Tenn.		
GASTROPODA	11	16	17	18	20	21	22	23	25	Wilcox	Wills Point	Kincaid	Wilcox	Naheola	Clayton	Undiff. Midway		
Fissurella (?) sp.							x	x										
Epitonium sp.			x	x		x		x										
Ampullina alabamiensis (Whitfield)								x		x	x	x	x	x				
Polinices harrisii Gardner		x	x	x	x	x	x											
Sinum sp.								x										
Turritella gardnerae LeBlanc (Ms)			?				x											
Turritella aldrichi Bowles			?	x			x							x	x			
Turritella sp.					x		x											
Calyptrophorus aldrichi Gardner			x	x			x	x				x		x				
Calyptrophorus sp. cf. C. trinodiferous Conrad						x	x											
Galeodea (?) sp.			x					x										
Priscoficus (Fulguroficus) juvenis (Whitfield)			x					x		x	x		x	x				
Mitrella sp. aff. M. alabamensis (Aldrich)							x											
Levifusus bellanus (Harris)							x						x					
Levifusus pagoda (Heilprin)				x			x			x			x					
Levifusus pagoda var. Harris							x							x				
Falsifusus harrisii LeBlanc (Ms)			x								x	x		x				
Cornulina triseralis LeBlanc (Ms)							x											
Athleta petrosa (Conrad)			x	x	x	x	x	x										
Turris rockacreekensis LeBlanc (Ms)							x				x							
Orthosurcula persa (Whitfield) var. pleasanthillensis LeBlanc (Ms)			x	x		x	x	x			x							
Orthosurcula longipersa (Harris)			x	?	x	x	x	x			x			x				
Orthosurcula sp. aff. O. adeona (Whitfield)							x	x										
Bullinella sp.							x											
PELECYPODA																		
Nucula ovula Lea							x			x			x	x				
Nuculana fiski Barry (Ms)			x	x			x	x										
Yoldia kindlei Harris				x			x									x		
Pinna natchitochensis Barry (Ms)				x			x	x			x							
Modiolus sp.								x										
Venericardia gardnerae Barry (Ms)			x	x		x	x	x	x									
Lucina sp.	x			x														
Cardium sp.						x		x										
Tellina estellensis Aldrich	x		x	x	?	x	x	x		x	x							
Corbula (Caryocorbula) sp.			x	x			x	x										
Corbula sp. B																		
Martesia sp.				x			x											

Figure 45. Check list of mollusca of Logansport formation (Midway) after LeBlanc and Barry.

Fig 45

Check List of Species of Foraminifera and Ostracoda from Upper Midway Sediments of Louisiana

	Midway Group								*Wilcox Group*
	*Texas**		*Louisiana†*						
	Upper	Lower	Map No. 8 GM Loc. 258	Map No. 10 GM Loc. 124	Map No. 12 GM Loc. 118	GM Loc. 198	Mississippi Upper Midway‡	Alabama§	Alabama‖
Foraminifera									
Haplophragmoides canariensis (d'Orbigny)	x	x		x	x				
Ammobaculites expansus Plummer	x		x	x	x				
A. midwayensis Plummer	x		x	x	x		x	x	
Textularia plummerae Lalicker	x				x			x	x
T. carinata d'Orbigny var. *expansa* Plummer	x				x				
Clavulinoides midwayensis Cushman	x	x	x		x			x	
Cristellaria subaculeata Cushman var. *tuberculata* Plummer	x				x	x			
Cristellaria turbinata Plummer	x					x		x	
Cristellaria sp. cf. *C. midwayensis* Plummer	x	x	x	x		x	x	x	x
Nonionella turgida (Williamson)	x				x	x			x
Bullopora chapmani (Plummer)	x	x						x	
B. laevis (Sollas)	x	x						x	
Cf. *Gumbelina midwayensis* Cushman					x			x	
Siphogeneroides eleganta (Plummer)	x	x			x			x	
Bolivina midwayensis Cushman					x			x	
Loxostoma applinae (Plummer)	x				x		x	x	
Angulogerina sp. cf. *A. wilcoxensis* (Cushman and Ponton)					x	x			x
Discorbis midwayensis Cushman					x			x	
Discorbis sp. cf. *D. infrequens* Plummer	x		x						
Rotalia soldani (d'Orbigny) var. *subangulata* Plummer	x	x			x	x			
Coleites reticulosus (Plummer)	x					x		x	x
Siphonina sp. cf. *S. prima* Plummer	x	x		x	x		x	x	
Globigerina compressa Plummer	x					x	x		x
G. pseudo-bulloides Plummer	x	x	x	x	x	x		x	
G. triloculinoides Plummer	x	x	x	x	x	x	x	x	x
Anomalina sp. cf. *A. welleri* (Plummer)	x		x	x					x
A. ammonoides (Reuss) var. *acuta* Plummer	x	x				x		x	x
A. sp. cf. *A. midwayensis* (Plummer)	x	x	x	x	x		x	x	
A. midwayensis (Plummer) var. *trochoidea* Plummer	x	x	x		x			x	
Ostracoda									
Cythereis prestwichiana Jones and Sherborn	x	x				x			x
Cytheromorpha scrobiculata Alexander	x	x				x			

fied species from the lower Eocene sediments of Alabama, Mississippi, and Texas are indicated.

The microfauna, as does the macrofauna (see Barry and LeBlanc), indicates an upper Midway age for the sediments stratigraphically below the *Ostrea thirsae* zone[9] in Louisiana and above the Midway black shale unit. The upper Midway sediments are exposed in northern Sabine Parish, in northern Natchitoches Parish, in western Red River Parish, in western Bienville Parish, in southern Caddo Parish, in all of De Soto Parish, and in parts of Panola and Shelby counties, Texas. No field work has been done yet in Bossier Parish to the north, where the upper Midway sediments also undoubtedly crop out.

A detailed report by the writer on the zonation, division, and correlation of the lower Eocene sediments of this area will appear in a future bulletin of the Louisiana Geological Survey on the geology of De Soto and Red River parishes, Louisiana.

The localities from which the best microfaunas have been obtained are here listed. They are indicated on the regional map (p. 734) by a circle.[10]

LOCALITIES OF MICROFAUNA

Map Number

2. GM Loc. 163 (RJL Loc. 2).—Road-cut on west side of Louisiana Highway 180 about 2½ miles northeast of Pleasant Hill in SW. ¼, SW. ¼ of Sec. 23, T. 10 N., R. 11 W., Sabine Parish. Fossils occur in large calcareous concretions in gray calcareous clays. Elevation, 323 feet

[9] The rarity of *Foraminifera* in Wilcox sediments correlative with, and immediately overlying, the *Ostrea thirsae* zone in Louisiana, unfortunately prevents a detailed comparison of foraminiferal faunas from these and underlying strata. However, Howe and Garrett in 1934 have confirmed by ostracodal studies that sediments correlative with the Nanafalia of Alabama are present in the Louisiana lower Eocene section. Currently, the representatives of the Coal Bluff and Ackerman strata of Alabama and Mississippi are undetermined in the Louisiana section. They may be represented by outcrops in the vicinity of Noble and Belmont, Sabine Parish, Louisiana, but a more exact determination must await additional detailed studies. Consequently, any attempt to draw an exact Midway-Wilcox contact in this area is unsatisfactory.

[10] Rufus J. LeBlanc and John O. Barry, "Fossiliferous Localities of Midway Group in Louisiana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, No. 4 (April, 1941), pp. 734-37, Fig. 1.

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* Helen Jeanne Plummer, "Foraminifera of the Midway Formation in Texas," *Univ. Texas Bull. 2644* (1926). 206 pp.

———, "Foraminiferal Evidence of the Midway-Wilcox Contact in Texas," *Univ. Texas Bull. 3201* (1932), pp. 51–68.

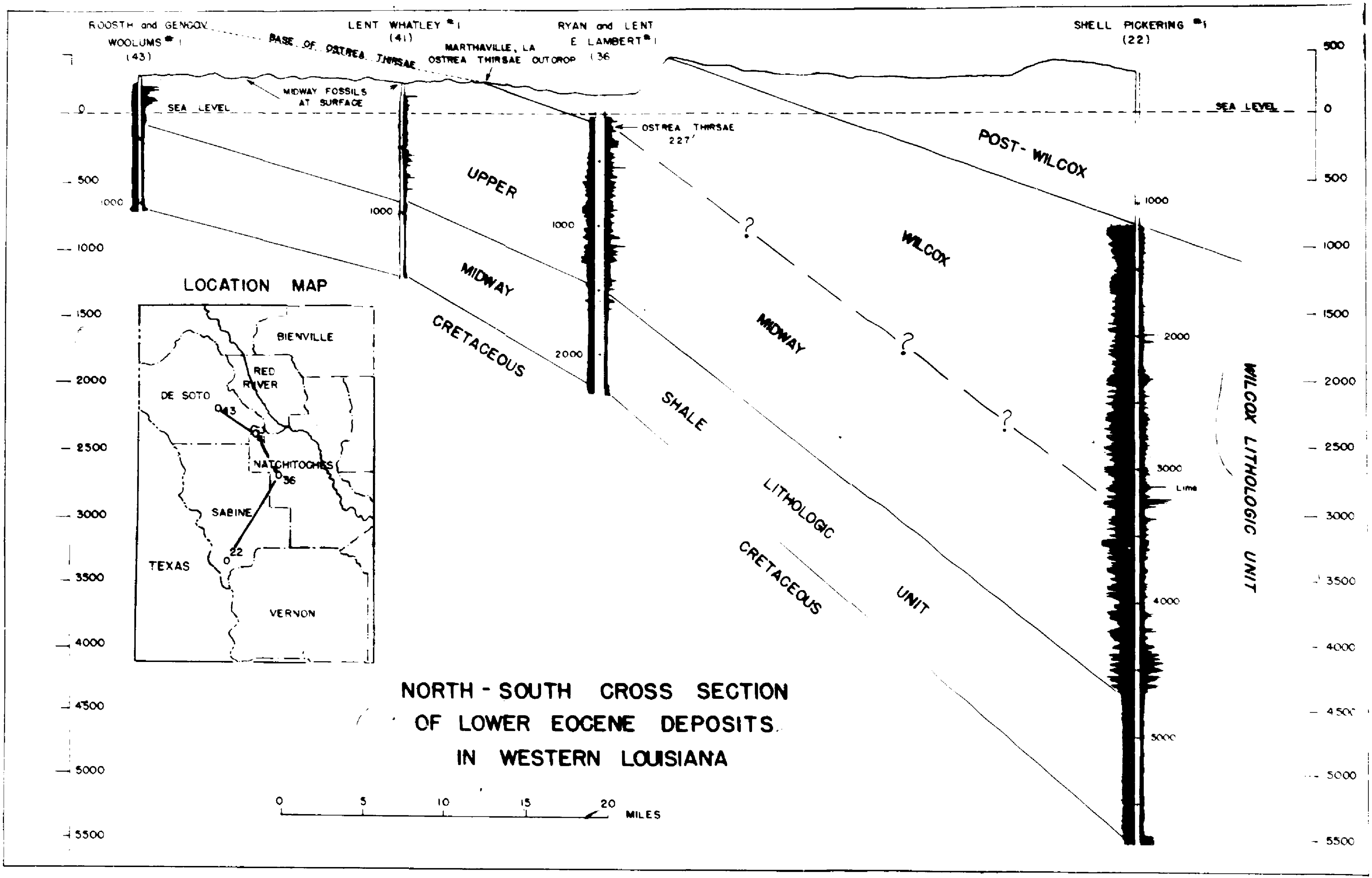
C. I. Alexander, "Ostracoda of the Midway Group (Eocene) of Texas," *Jour. Paleontology*, Vol. 8, No. 2 (1934), pp. 206–38.

† Compare: C. I. Alexander, "Stratigraphy of the Midway Group (Eocene) of Southwestern Arkansas and Northwestern Louisiana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 5 (1935), pp. 696–99.

‡ W. O. George and H. X. Bay, "Subsurface Data on Covington County, Mississippi," *Bull. Amer Assoc. Petrol. Geol.*, Vol. 19, No. 10 (1935), pp. 1148–61.

§ J. A. Cushman, "Midway Foraminifera from Alabama," *Cushman Lab. Foram. Research Contrib.*, Vol. 16, Pt. 3 (1940), pp. 51–73.

‖ J. A. Cushman and G. M. Ponton, *op. cit.* (1932).
J. A. Cushman and J. B. Garrett, *op. cit.* (1939).
L. D. Toulmin, "The Salt Mountain Limestone of Alabama," *Alabama Geol. Survey Bull. 46* (1940). 126 pp.



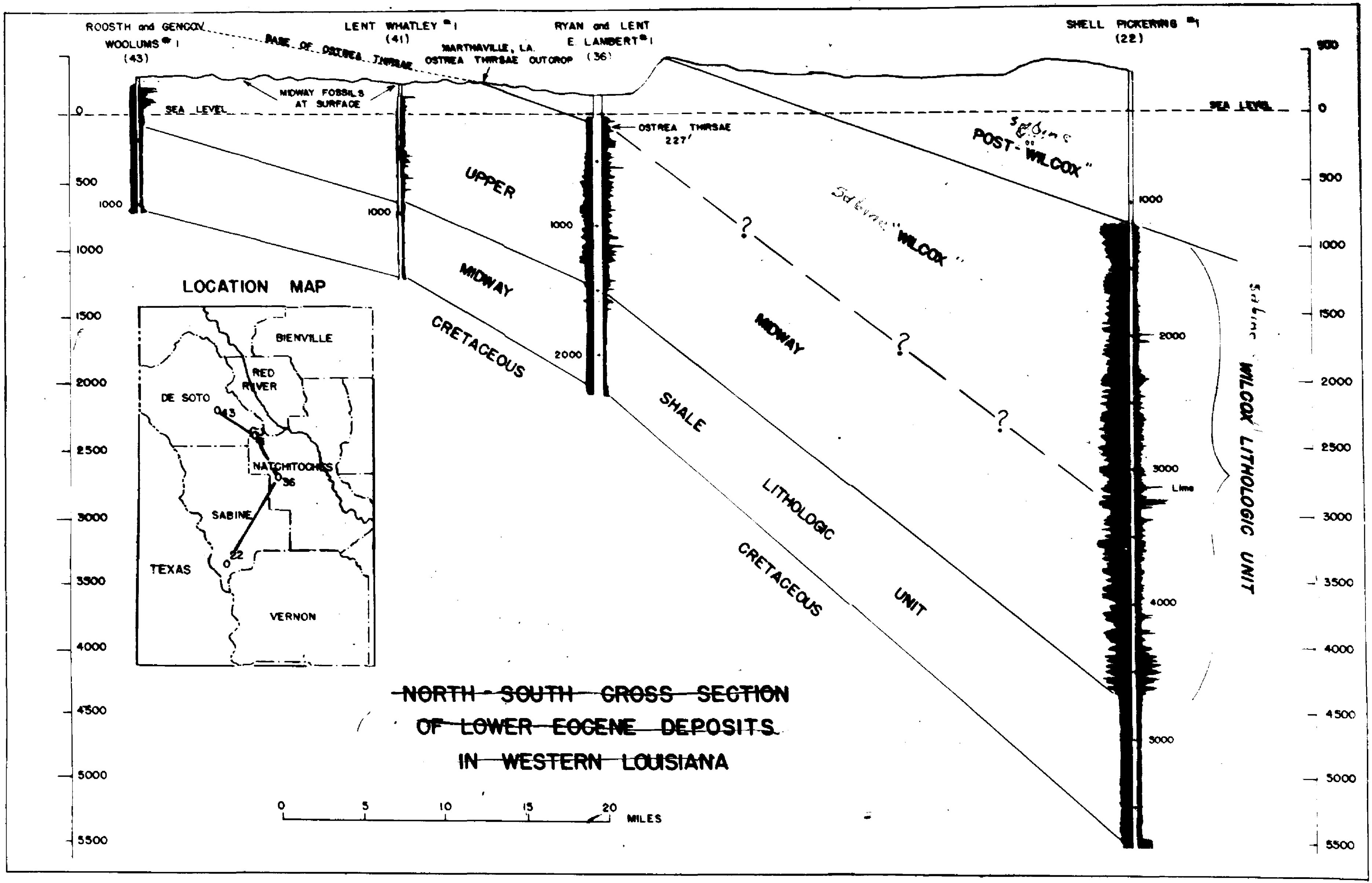
NORTH - SOUTH CROSS SECTION
OF LOWER EOCENE DEPOSITS
IN WESTERN LOUISIANA

Paleocene and

Fig. 50. North-south cross section of ~~Lower~~ Eocene deposits of western Louisiana showing surface and subsurface relationships of Sabine ("Wilcox") and Midway contact (after Fisk, 1941, and unpublished manuscript).

Well numbers refer to fig. 12

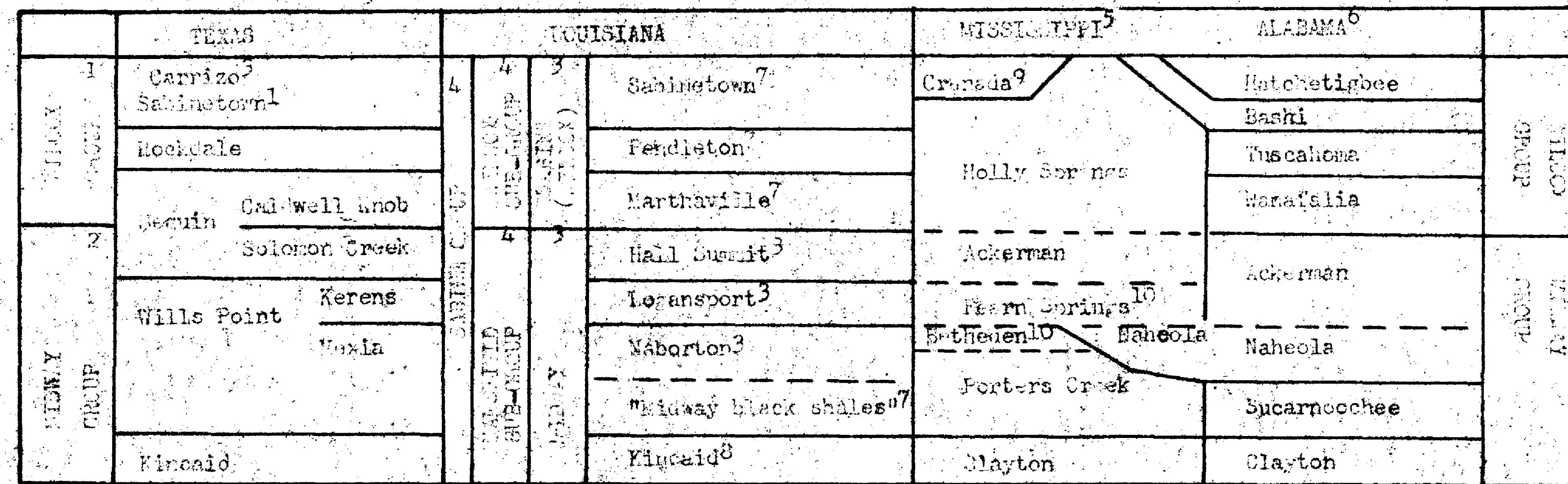
See original in [illegible]



~~NORTH-SOUTH CROSS SECTION~~
~~OF LOWER EOCENE DEPOSITS~~
~~IN WESTERN LOUISIANA~~

Figure 23

LOWER EOCENE CORRELATION CHART



1 Claypool, C. B., The Wilcox of Central Texas: Abstract of thesis (Univ. Illinois) Urbana, Illinois, p. 6, 1933.

2. Gardner, Julia, The Midway group of Texas: Univ. Texas Bull. 3301, p. 22, 1933.

3 Papers by Fisk, Barry, LeBlanc, and Murray (1941).

4. Howe, H. V., and Garrett, J. B., Louisiana Sabine Eocene Ostracoda: Louisiana Geol. Survey Bull. 4, p. 9, 1934.

5 Grim, R. E., Eocene sediments of Mississippi: Mississippi Geol. Survey Bull. 30, pp. 29, 50, 1936.

6 Cooke, C. W., The Cenozoic formations: Alabama Special Report 14, pp. 253-258, 1926.

7. Present report.

8 Alexander, C. I., Stratigraphy of the Midway Group (Eocene) of southwest Arkansas and northwest Louisiana: Bull. Amer. Assoc. Petroleum Geologists, vol. 19, pp. 696-699, 1935; and present report.

9 Grenada now recognized by Mississippi Geol. Survey as comprising upper Holly Springs, Tallahatta, Winona, Zilpha, and probably Kosciusko. U. S. G. S. - Water Supply Paper No. 576.

10 Mellen, F. F., Winston County Mineral Resources: Miss. Geol. Survey, Bull. 38, pp. 30, 1939.

Other References

Blanpied, B. W., and Hazzard, R. T., Guide Book 14th Annual Field Trip of Shreveport Geological Society, p. 128, 1939.

Moody, C. L., Tertiary history of region of Sabine Uplift, Louisiana: Bull. Amer. Assoc. Petroleum Geologists, vol. 15, pp. 531-551, 1931.

Plummer, F. B., The Cenozoic systems in Texas: Univ. Texas Bull. 3232, Part 3, pp. 531-606, 1933.

Wendlandt, E. A., and Knebel, G. M., Lower Claiborne of East Texas, etc: Bull. Amer. Assoc. Petroleum Geologists, vol. 13, pp. 1347-1375, 1929.

Fig 23

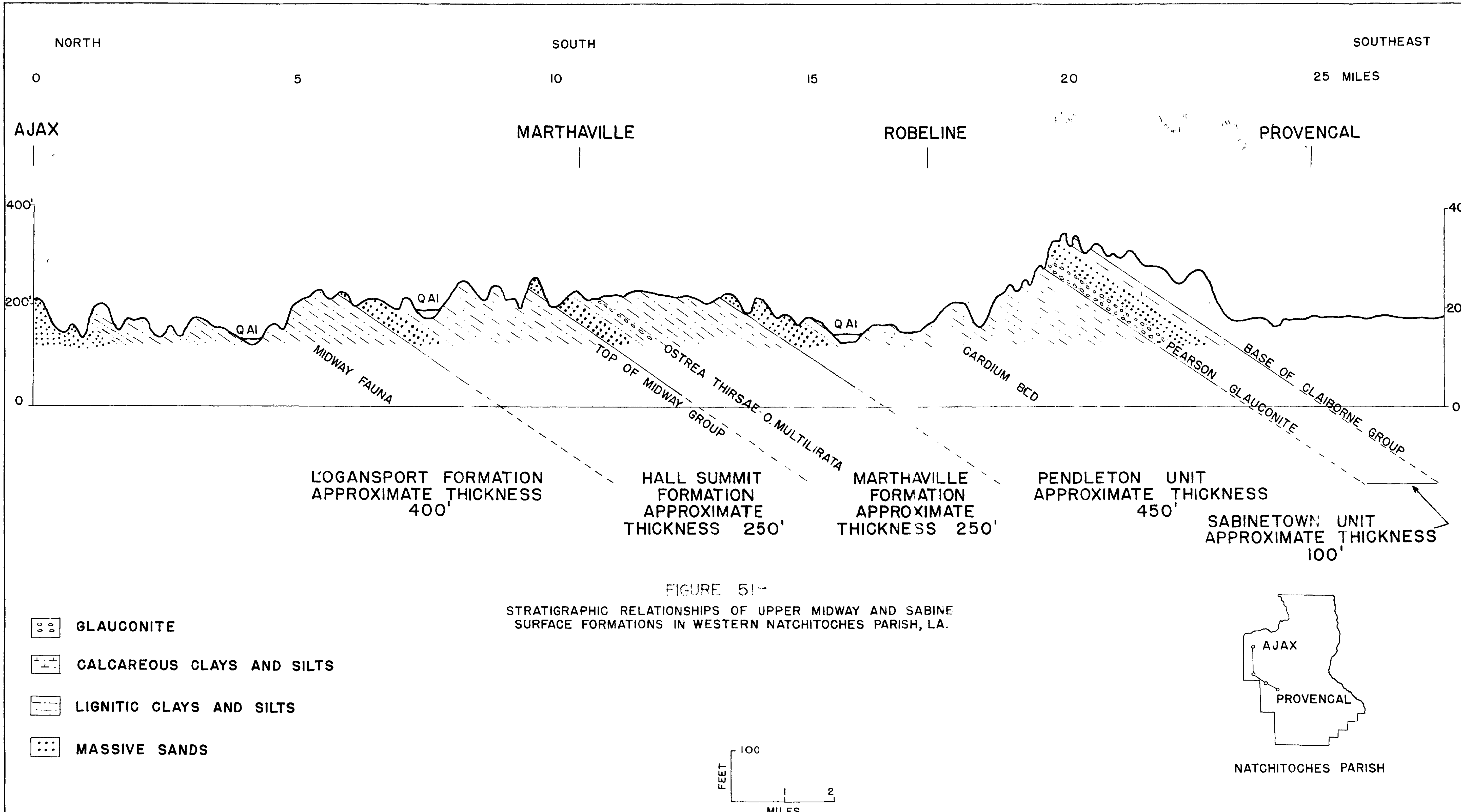


FIGURE 51

STRATIGRAPHIC RELATIONSHIPS OF UPPER MIDWAY AND SABINE SURFACE FORMATIONS IN WESTERN NATCHITOCHES PARISH, LA.

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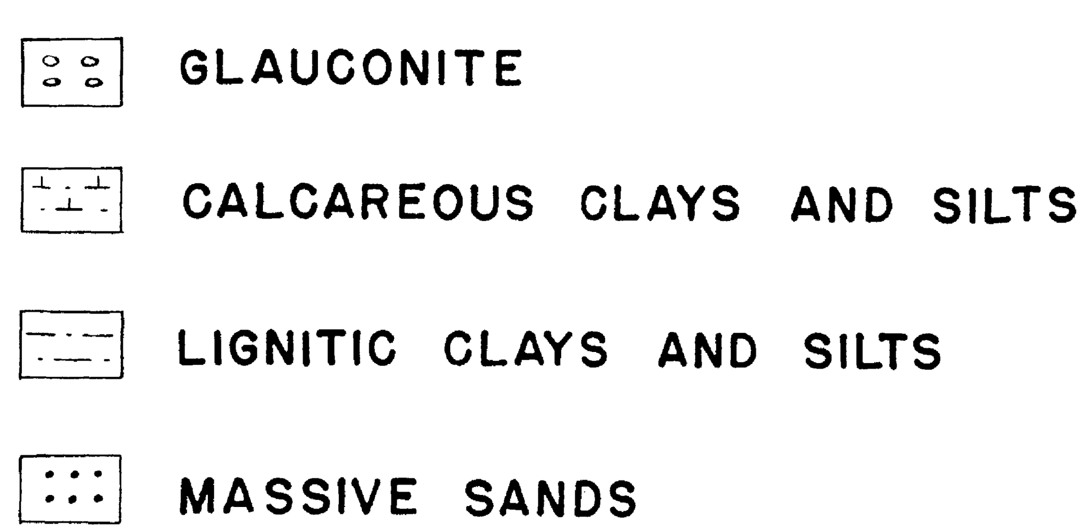
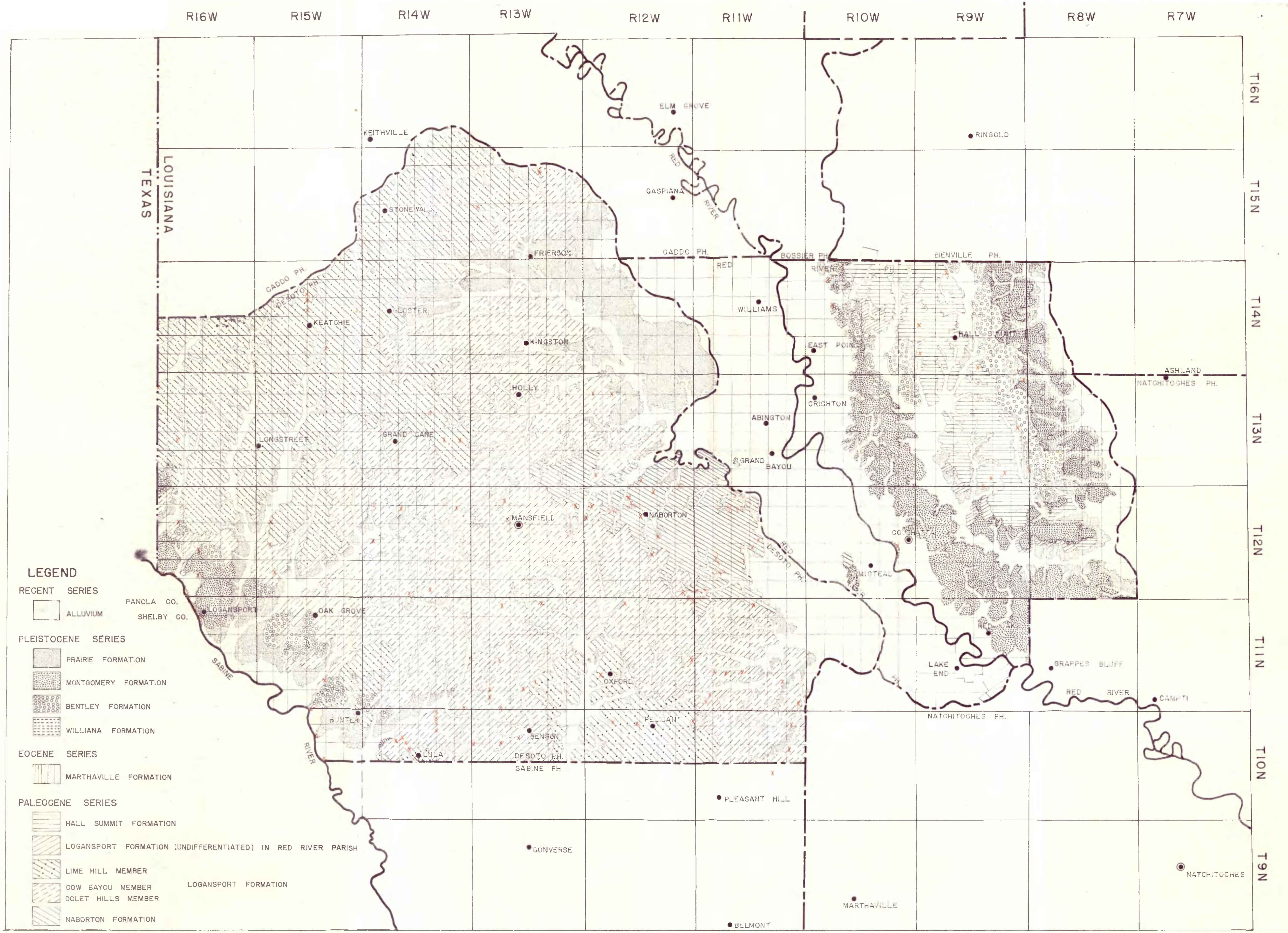
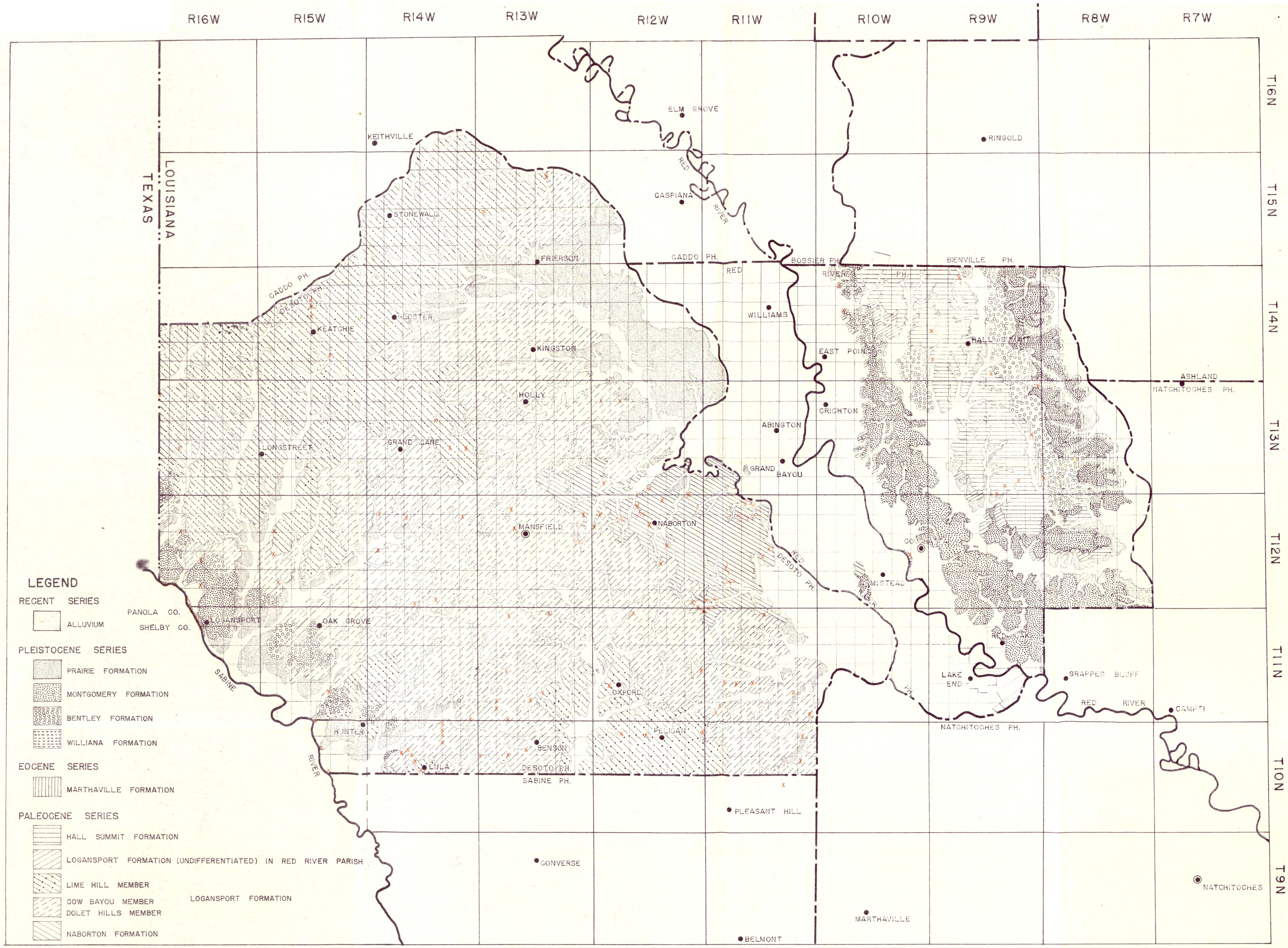
STRATIGRAPHIC RELATIONSHIPS OF UPPER MIDWAY AND SABINE SURFACE FORMATIONS IN WESTERN NATCHITOCHES PARISH, LA.





PLATES I AND II - GEOLOGIC MAPS OF DESOTO AND RED RIVER PARISHES, LOUISIANA



PLATES I AND II – GEOLOGIC MAPS OF DESOTO AND RED RIVER PARISHES, LOUISIANA

Plates

I & II

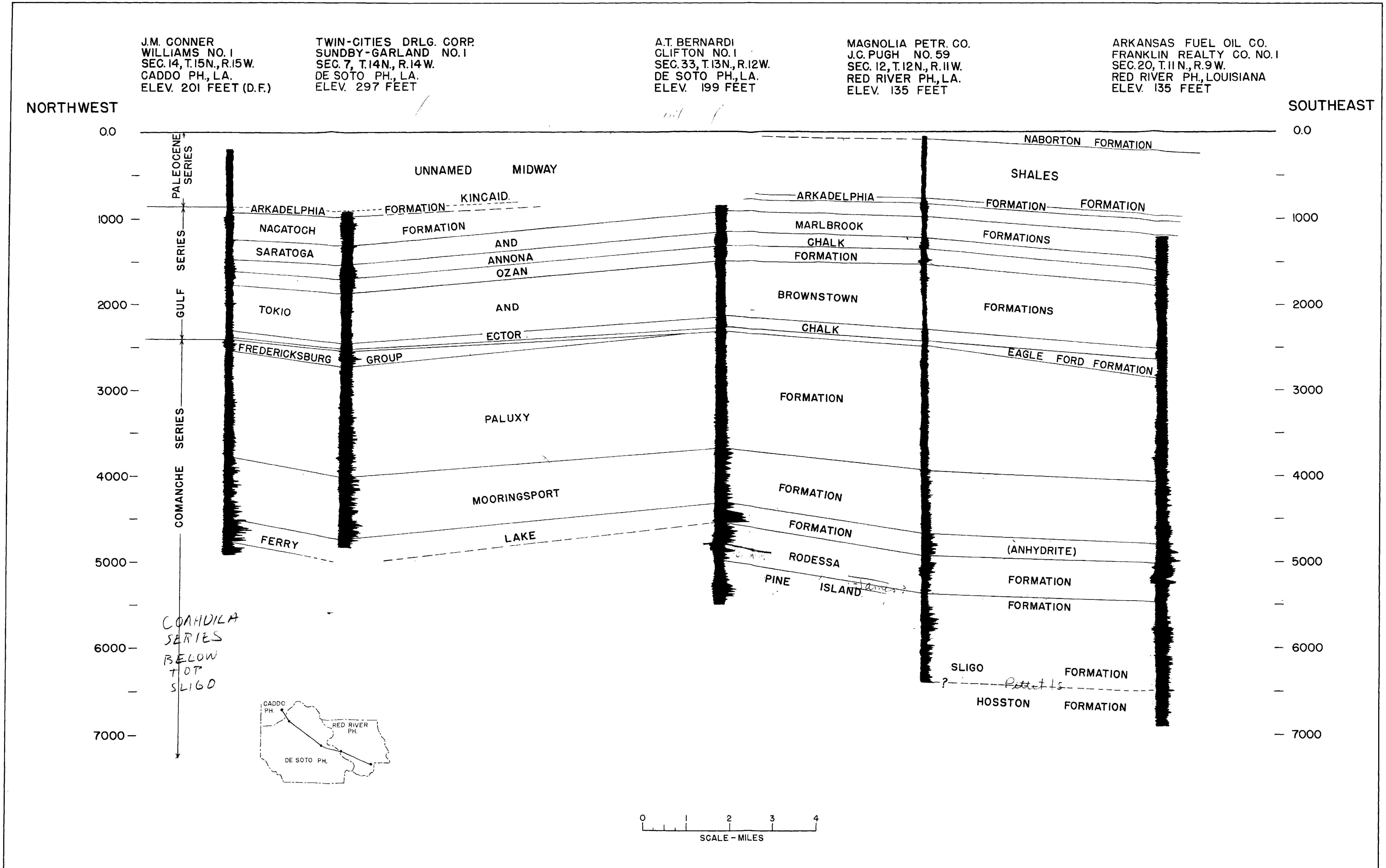


FIGURE 10. NORTHWEST-SOUTHEAST ELECTRICAL LOG SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

FIGURE 10. NORTHWEST-SOUTHEAST ELECTRICAL LOG SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

PLATE — IV

REGIONAL GEOLOGIC MAP SHOWING APPROXIMATE AREAL EXTENT OF UPPER MIDWAY AND SABINE FORMATIONS AND IMPORTANT FOSSIL LOCALITIES IN DE SOTO AND RED RIVER PARISHES, LOUISIANA AND ADJACENT AREAS

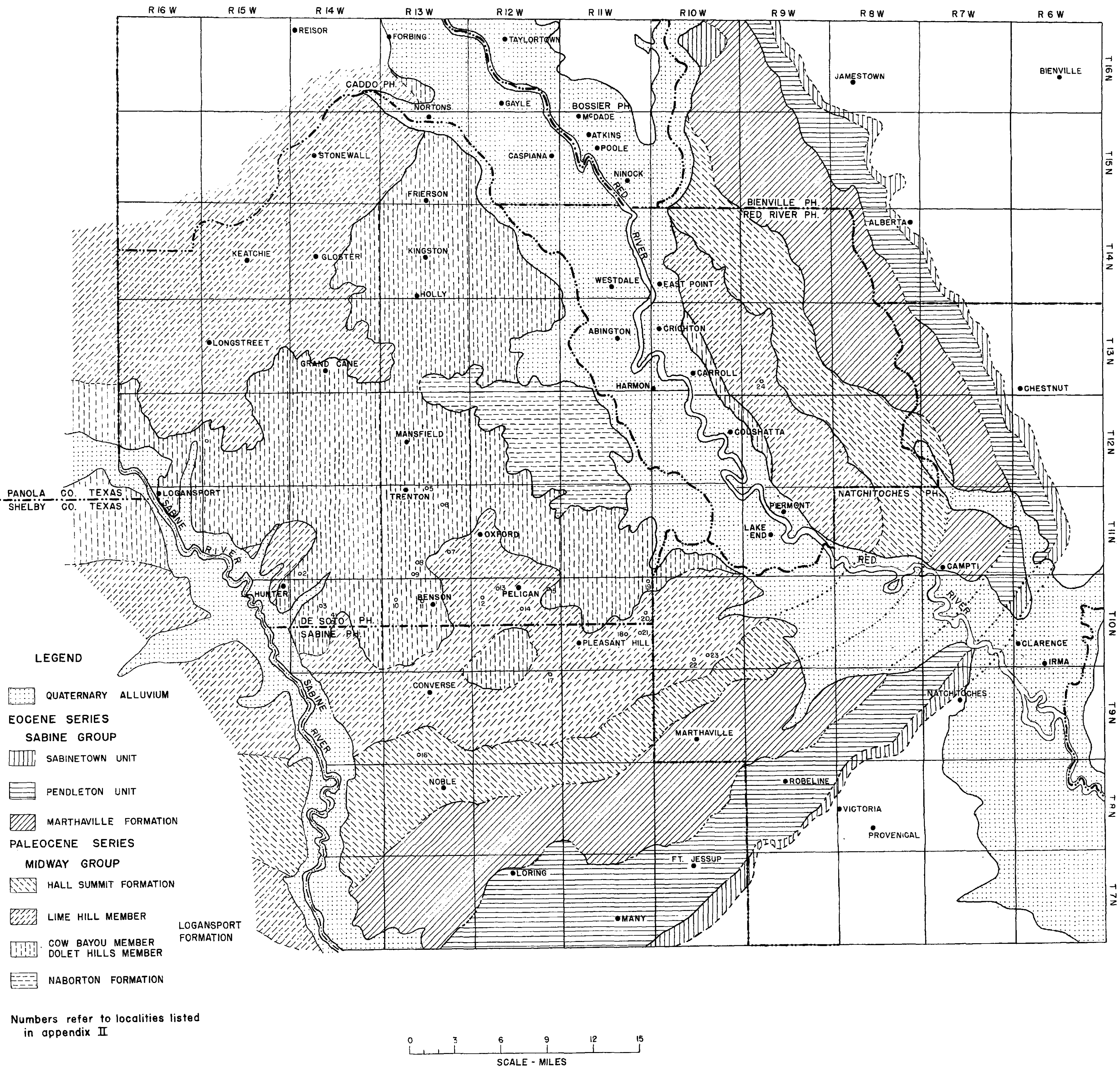
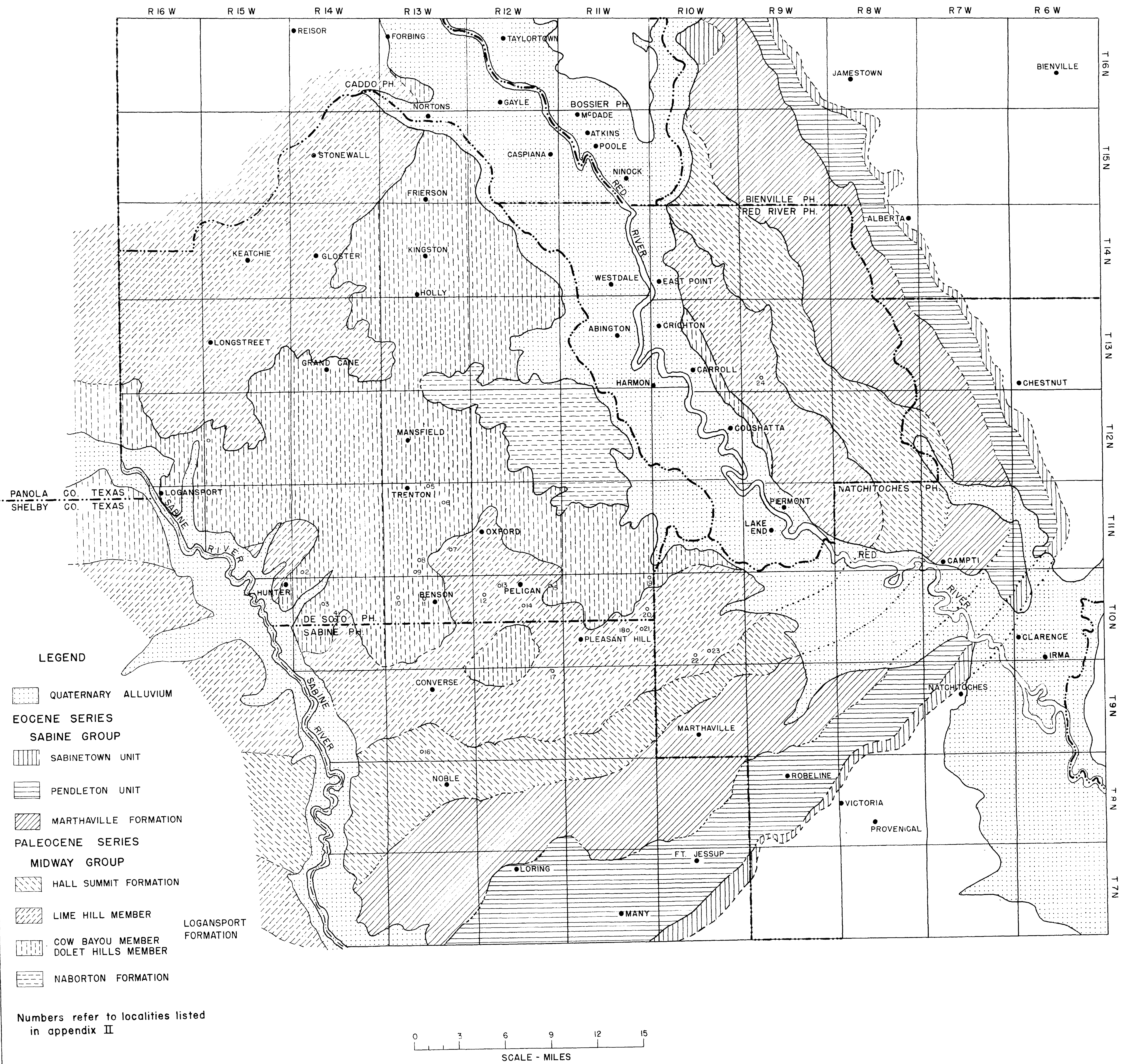


PLATE — IV

REGIONAL GEOLOGIC MAP SHOWING APPROXIMATE AREAL EXTENT OF UPPER MIDWAY AND SABINE FORMATIONS AND IMPORTANT FOSSIL LOCALITIES IN DE SOTO AND RED RIVER PARISHES, LOUISIANA AND ADJACENT AREAS



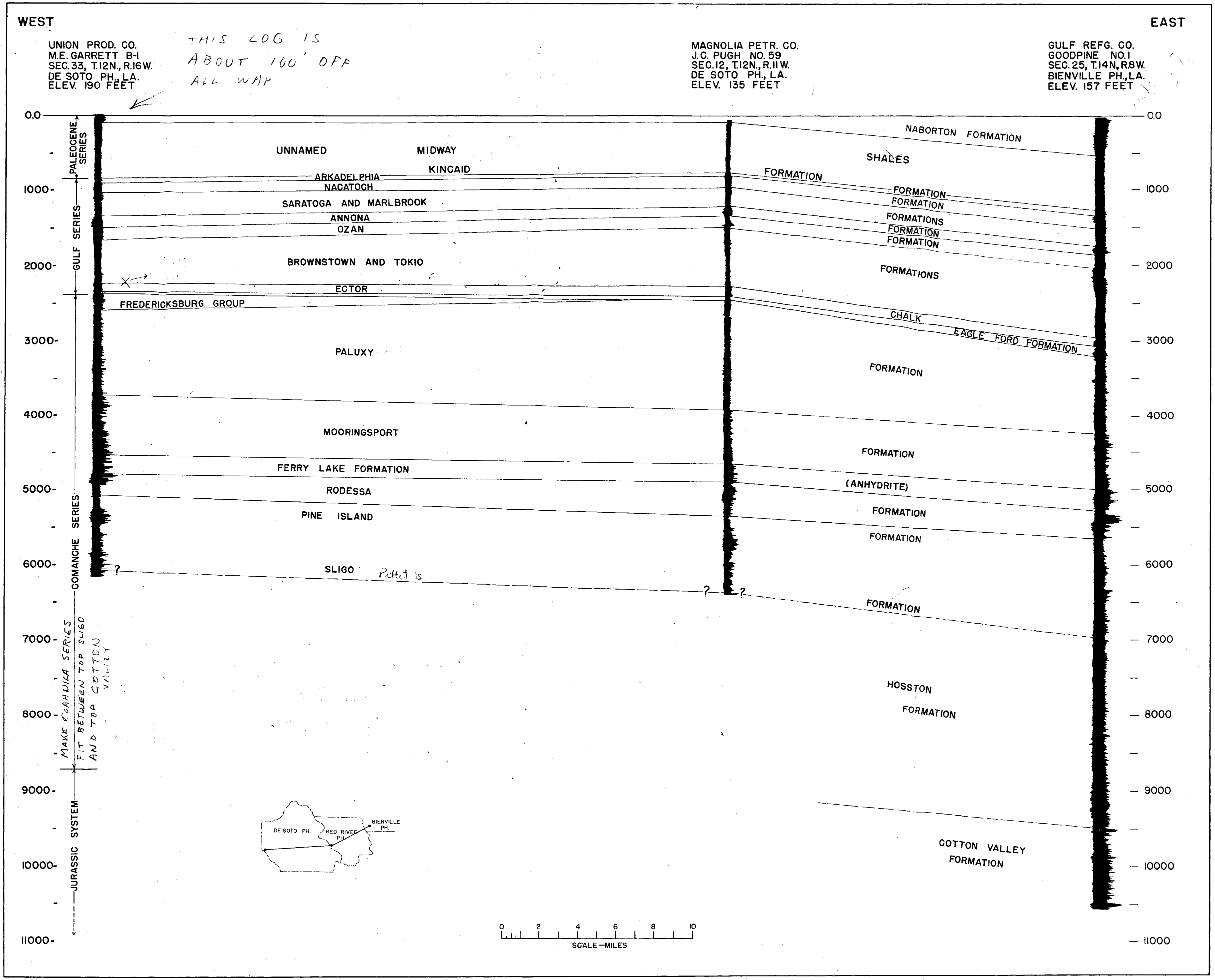


FIGURE 7. EAST-WEST ELECTRICAL LOG SECTION SHOWING MIDWAY-CRETACEOUS RELATIONSHIPS

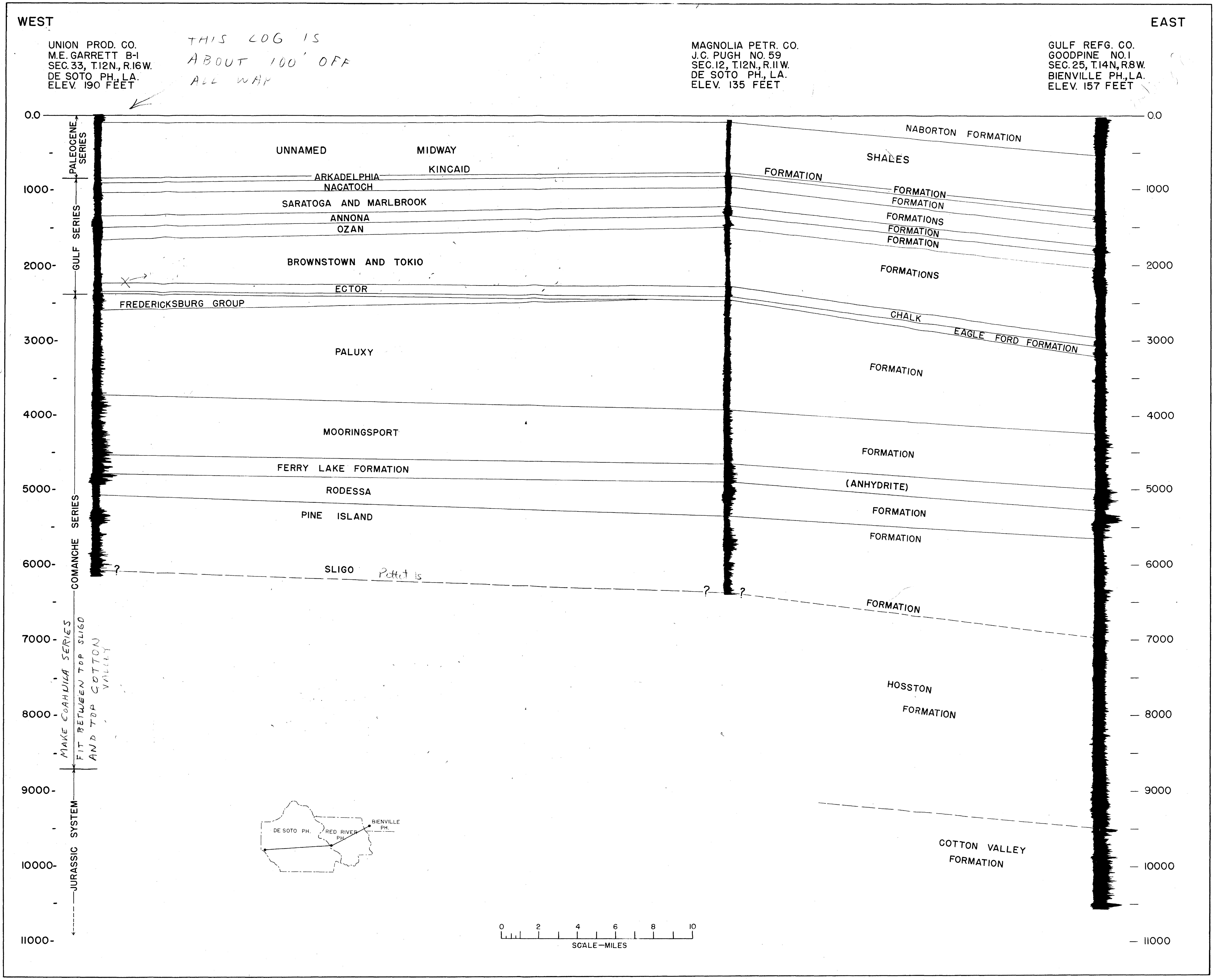


FIGURE 7. EAST - WEST ELECTRICAL LOG SECTION SHOWING MIDWAY - CRETACEOUS RELATIONSHIPS